US Army Corps of Engineers®
Walla Walla District

FINAL

Lower Snake River Juvenile Salmon Migration Feasibility Report/ Environmental Impact Statement

APPENDIX R
Historical Perspectives

February 2002

FEASIBILITY STUDY DOCUMENTATION

	Document Title
Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement	
Appendix A (bound with B)	Anadromous Fish Modeling
Appendix B (bound with A)	Resident Fish
Appendix C	Water Quality
Appendix D	Natural River Drawdown Engineering
Appendix E	Existing Systems and Major System Improvements Engineering
Appendix F (bound with G, H)	Hydrology/Hydraulics and Sedimentation
Appendix G (bound with F, H)	Hydroregulations
Appendix H (bound with F, G)	Fluvial Geomorphology
Appendix I	Economics
Appendix J	Plan Formulation
Appendix K	Real Estate
Appendix L (bound with M)	Lower Snake River Mitigation History and Status
Appendix M (bound with L)	Fish and Wildlife Coordination Act Report
Appendix N (bound with O, P)	Cultural Resources
Appendix O (bound with N, P)	Public Outreach Program
Appendix P (bound with N, O)	Air Quality
Appendix Q (bound with R, T)	Tribal Consultation and Coordination
Appendix R (bound with Q, T)	Historical Perspectives
Appendix S*	Snake River Maps
Appendix T (bound with R, Q)	Clean Water Act, Section 404(b)(1) Evaluation
Appendix U	Response to Public Comments

*Appendix S, Lower Snake River Maps, is bound separately (out of order) to accommodate a special 11 x 17 format.

The documents listed above, as well as supporting technical reports and other study information, are available on our website at http://www.nww.usace.army.mil/lsr. Copies of these documents are also available for public review at various city, county, and regional libraries.

STUDY OVERVIEW

Purpose and Need

Between 1991 and 1997, due to declines in abundance, the National Marine Fisheries Service (NMFS) made the following listings of Snake River salmon or steelhead under the Endangered Species Act (ESA) as amended:

- sockeye salmon (listed as endangered in 1991)
- spring/summer chinook salmon (listed as threatened in 1992)
- fall chinook salmon (listed as threatened in 1992)
- steelhead (listed as threatened in 1997).

In 1995, NMFS issued a Biological Opinion on operations of the Federal Columbia River Power System (FCRPS). Additional opinions were issued in 1998 and 2000. The Biological Opinions established measures to halt and reverse the declines of ESA-listed species. This created the need to evaluate the feasibility, design, and engineering work for these measures.

The Corps implemented a study (after NMFS' Biological Opinion in 1995) of alternatives associated with lower Snake River dams and reservoirs. This study was named the Lower Snake River Juvenile Salmon Migration Feasibility Study (Feasibility Study). The specific purpose and need of the Feasibility Study is to evaluate and screen structural alternatives that may increase survival of juvenile anadromous fish through the Lower Snake River Project (which includes the four lowermost dams operated by the Corps on the Snake River—Ice Harbor, Lower Monumental, Little Goose, and Lower Granite Dams) and assist in their recovery.

Development of Alternatives

The Corps' response to the 1995 Biological Opinion and, ultimately, this Feasibility Study, evolved from a System Configuration Study (SCS) initiated in 1991. The SCS was undertaken to evaluate the technical, environmental, and economic effects of potential modifications to the configuration of Federal dams and reservoirs on the Snake and Columbia Rivers to improve survival rates for anadromous salmonids.

The SCS was conducted in two phases. Phase I was completed in June 1995. This phase was a reconnaissance-level assessment of multiple concepts including drawdown, upstream collection, additional reservoir storage, migratory canal, and other alternatives for improving conditions for anadromous salmonid migration.

The Corps completed a Phase II interim report on the Feasibility Study in December 1996. The report evaluated the feasibility of drawdown to natural river levels, spillway crest, and other improvements to existing fish passage facilities.

Based in part on a screening of actions conducted for the Phase I report and the Phase II interim report, the study now focuses on four courses of action:

- Existing Conditions
- Maximum Transport of Juvenile Salmon

- Major System Improvements
- Dam Breaching.

The results of these evaluations are presented in the combined Feasibility Report (FR) and Environmental Impact Statement (EIS). The FR/EIS provides the support for recommendations that will be made regarding decisions on future actions on the Lower Snake River Project for passage of juvenile salmonids. This appendix is a part of the FR/EIS.

Geographic Scope

The geographic area covered by the FR/EIS generally encompasses the 140-mile long lower Snake River reach between Lewiston, Idaho and the Tri-Cities in Washington. The study area does slightly vary by resource area in the FR/EIS because the affected resources have widely varying spatial characteristics throughout the lower Snake River system. For example, socioeconomic effects of a permanent drawdown could be felt throughout the whole Columbia River Basin region with the most effects taking place in the counties of southwest Washington. In contrast, effects on vegetation along the reservoirs would be confined to much smaller areas.

Identification of Alternatives

Since 1995, numerous alternatives have been identified and evaluated. Over time, the alternatives have been assigned numbers and letters that serve as unique identifiers. However, different study groups have sometimes used slightly different numbering or lettering schemes and this has led to some confusion when viewing all the work products prepared during this long period. The primary alternatives that are carried forward in the FR/EIS currently involve the following four major courses of action:

Alternative Name	PATH[1/] Number	Corps Number	FR/EIS Number
Existing Conditions	A-1	A-1	1
Maximum Transport of Juvenile Salmon	A-2	A-2a	2
Major System Improvements	A-2’	A-2d	3
Dam Breaching	A-3	A-3a	4

[1/] Plan for Analyzing and Testing Hypotheses

Summary of Alternatives

The **Existing Conditions Alternative** consists of continuing the fish passage facilities and project operations that were in place or under development at the time this Feasibility Study was initiated. The existing programs and plans underway would continue unless modified through future actions. Project operations include fish hatcheries and Habitat Management Units (HMUs) under the Lower Snake River Fish and Wildlife Compensation Plan (Comp Plan), recreation facilities, power generation, navigation, and irrigation. Adult and juvenile fish passage facilities would continue to operate.

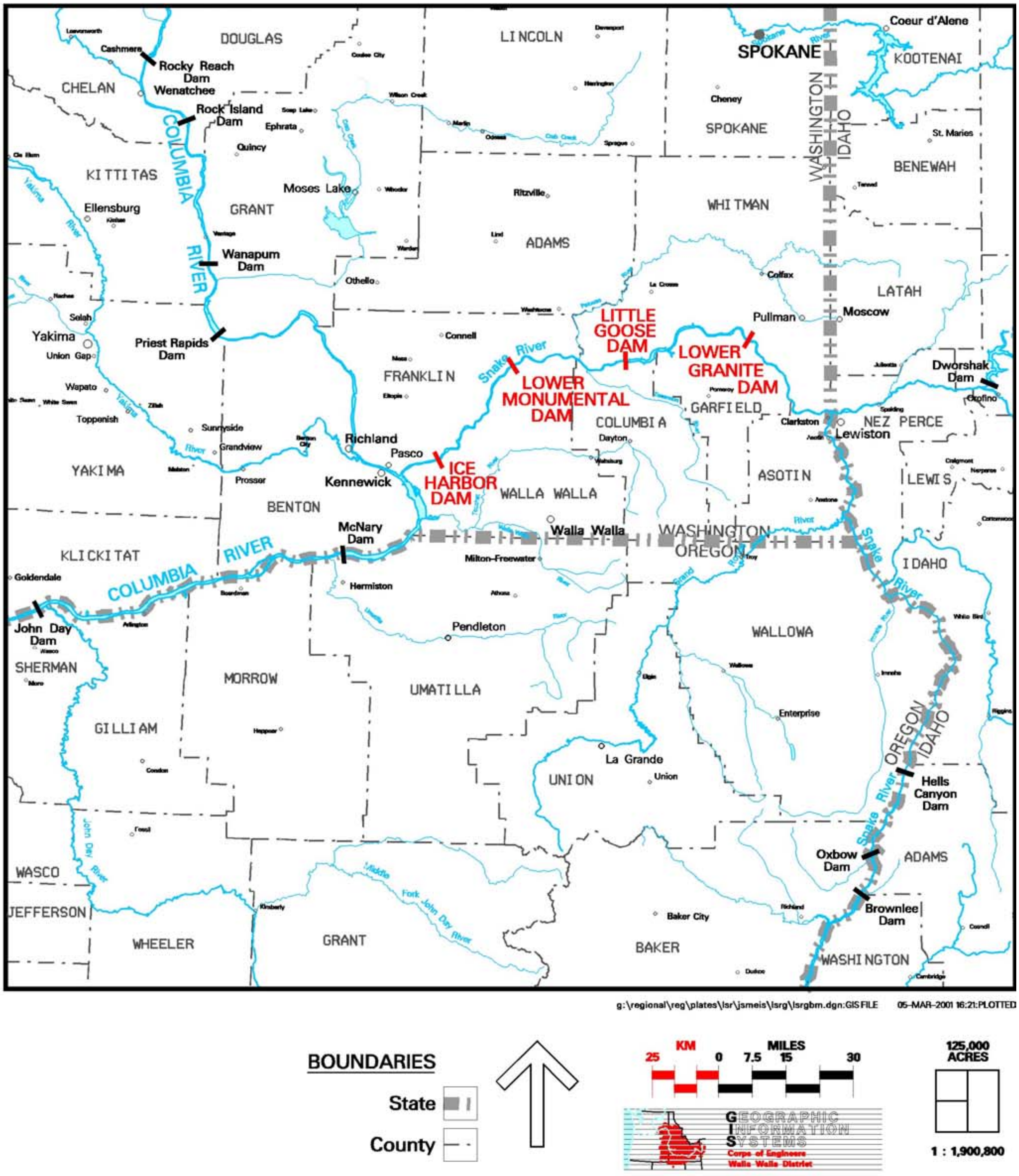
The **Maximum Transport of Juvenile Salmon Alternative** would include all of the existing or planned structural and operational configurations from the Existing Conditions Alternative. However, this alternative assumes that the juvenile fishway systems would be operated to maximize fish transport from Lower Granite, Little Goose, and Lower Monumental and that voluntary spill would not be used to bypass fish through the spillways (except at Ice Harbor). To accommodate this maximization of transport, some measures would be taken to upgrade and improve fish handling facilities.

The **Major System Improvements Alternative** would provide additional improvements to what is considered under the Existing Conditions Alternative. These improvements would be focused on using surface bypass facilities such as surface bypass collectors (SBCs) and removable spillway weirs (RSWs) in conjunction with extended submerged bar screens (ESBSs) and a behavioral guidance structure (BGS). The intent of these facilities would be to provide more effective diversion of juvenile fish away from the turbines. Under this alternative, an adaptive migration strategy would allow flexibility for either in-river migration or collection and transport of juvenile fish downstream in barges and trucks.

The **Dam Breaching Alternative** has been referred to as the "Drawdown Alternative" in many of the study groups since late 1996 and the resulting FR/EIS reports. These two terms essentially refer to the same set of actions. Because the term drawdown can refer to many types of drawdown, the term dam breaching was created to describe the action behind the alternative. The Dam Breaching Alternative would involve significant structural modifications at the four lower Snake River dams, allowing the reservoirs to be drained and resulting in a free-flowing yet controlled river. Dam breaching would involve removing the earthen embankment sections of the four dams and then developing a channel around the powerhouses, spillways, and navigation locks. With dam breaching, the navigation locks would no longer be operational and navigation for large commercial vessels would be eliminated. Some recreation facilities would close while others would be modified and new facilities could be built in the future. The operation and maintenance of fish hatcheries and HMUs would also change, although the extent of change would probably be small and is not known at this time.

Authority

The four Corps dams of the lower Snake River were constructed and are operated and maintained under laws that may be grouped into three categories: 1) laws initially authorizing construction of the project, 2) laws specific to the project passed subsequent to construction, and 3) laws that generally apply to all Corps reservoirs.



LOWER SNAKE RIVER
Juvenile Salmon Migration Feasibility Study

REGIONAL BASE MAP

US Army Corps
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Walla Walla District

Final
Lower Snake River Juvenile Salmon Migration Feasibility Report/ Environmental Impact Statement

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Appendix R
Historical Perspectives

Produced by

Foster Wheeler Environmental Corporation and Historical Research Associates

Produced for

U.S. Army Corps of Engineers
Walla Walla District

February 2002

FOREWORD

Appendix R was prepared by Foster Wheeler Environmental Corporation and Historical Research Associates in conjunction with the U.S. Army Corps of Engineers' (Corps) study team. This appendix is one part of the overall effort of the Corps to prepare the Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement (FR/EIS).

The Corps has reached out to regional stakeholders (Federal agencies, tribes, states, local governmental entities, organizations, and individuals) during the development of the FR/EIS and appendices. This effort resulted in many of these regional stakeholders providing input and comments, and even drafting work products or portions of these documents. This regional input provided the Corps with an insight and perspective not found in previous processes. A great deal of this information was subsequently included in the FR/EIS and appendices; therefore, not all of the opinions and/or findings herein may reflect the official policy or position of the Corps.

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ACRONYMS AND ABBREVIATIONS

ANCOOR	Analytical Coordination Work Group
BA	biological assessment
BOR	U.S. Bureau of Reclamation
BPA	Bonneville Power Administration
CEQ	Council on Environmental Quality
Corps	U.S. Army Corps of Engineers
CRBFWP	Columbia River Basin Fish and Wildlife Program
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FCRPS	Federal Columbia River Power System
FEIS	Final Environmental Impact Statement
flip lips	spillway flow deflectors
FR	Feasibility Report
FR/EIS	Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement
IDFG	Idaho Department of Fish and Game
IDFG v. NMFS	*Idaho Department of Fish and Game v. National Marine Fisheries Service*
ISG	Independent Scientific Group
MOA	Memorandum of Agreement
MOP	minimum operating pool
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NPPC	Northwest Power Planning Council
OA/EIS	Columbia River Salmon Flow Measures Options Analysis/Environmental Impact Statement
PATH	Plan for Analyzing and Testing Hypotheses
PNCA	Pacific Northwest Coordination Agreement
ROD	Record of Decision
SBC	surface bypass collector
SCS	System Configuration Study
SEIS	Supplemental Environmental Impact Statement
SOR	System Operation Review
SOS	System Operating Strategies
SRSRT	Snake River Salmon Recovery Team
TAG	Technical Advisory Group
USFWS	U.S. Fish and Wildlife Service

ENGLISH TO METRIC CONVERSION FACTORS

To Convert From	To	Multiply By
LENGTH CONVERSIONS:		
Inches	Millimeters	25.4
Feet	Meters	0.3048
Miles	Kilometers	1.6093
AREA CONVERSIONS:		
Acres	Hectares	0.4047
Acres	Square meters	4047
Square Miles	Square kilometers	2.590
VOLUME CONVERSIONS:		
Gallons	Cubic meters	0.003785
Cubic yards	Cubic meters	0.7646
Acre-feet	Hectare-meters	0.1234
Acre-feet	Cubic meters	1234
OTHER CONVERSIONS:		
Feet/mile	Meters/kilometer	0.1894
Tons	Kilograms	907.2
Tons/square mile	Kilograms/square kilometer	350.2703
Cubic feet/second	Cubic meters/sec	0.02832
Degrees Fahrenheit	Degrees Celsius	(Deg F –32) x (5/9)

Executive Summary

This appendix provides a historical perspective on the development and changes in hydropower, habitat, hatcheries, and harvest since the mid-19th century and a summary of significant events and documents related to salmon restoration efforts in the Federal Columbia River Power System (FCRPS) since 1990.

The public perception of what is meant by “conservation” has changed significantly since the mid-19th century. To the Euroamericans that first arrived on the Columbia and Snake Rivers, conservation meant that natural resources were used in an efficient and sustainable manner. Resources such as soil (for agriculture), timber, fish, stream beds (for mining), and water were considered economic commodities. The development of railroads increased access to both natural resources and to expanding markets eager to consume these commodities. Many natural resources seemed inexhaustible and the ecological effects of their exploitation were poorly understood.

This early view of natural resources and the desire for economic expansion resulted in the development of the timber, mining, and agricultural industries. During the development of these industries and the general expansion of the population in the Columbia River Basin, salmon habitat quality and quantity declined as a result of reductions in large woody debris, increases in sediment fines, direct (e.g., dikes, channel straightening, etc.) and indirect (i.e., from flow and sediment load) changes in stream morphology, modifications of water flow, and decreased water quality. At the same time technological advances made the harvesting and storage of salmon more efficient and widely available to the growing American population. No significant regulation of these industries other than fisheries occurred until the latter half of the 20th century.

The first of the Federal dams, Bonneville Dam, was constructed in 1938 and additional multipurpose dams were built through the 1970s. The FCRPS and Bureau of Reclamation (BOR) dams provided cheap electricity, flood control, irrigation, and in-river water transportation to the region. The hydrosystem contributed to the development of industries such as aluminum smelting that relied heavily on electricity, and those that needed water during seasons with naturally low rainfall and streamflow. Many dams were built under the assumption that technology in the form of fish passage facilities and hatcheries could mitigate for adverse effects to salmon populations.

Initially, only a small minority of the public was concerned about the adverse effects to salmon from hydropower, industry, fish harvest, and hatchery development. However, in the 1970s, the decade that included enactment of the Endangered Species Act (ESA) and the Clean Water Act, the public perception of “conservation” began to shift more towards the conservation of species and ecosystems for their own sake. In addition, it became more widely recognized during succeeding decades that the cumulative effects of economic development in the Columbia River Basin were causing declines in highly valued species such as salmon to the point where many populations were on the brink of extirpation or were already gone.

Federal, state, local government, and citizen efforts to recover salmon populations accelerated during the 1990s. The first significant event of the 1990s was the Northwest Salmon Summit, which was convened in 1990 to address the problem of declining salmon stocks and to reach a consensus among diverse Pacific Northwest interests.

In the ensuing years, three species of Northwest anadromous fish were listed as threatened or endangered on the Snake River: sockeye salmon were listed as endangered in 1991; chinook were listed as threatened in 1992; and steelhead were listed as threatened in 1996. Overall, 12 separate runs are currently listed in the Columbia River System.

Many agencies and groups are involved in the anadromous fish issues of the Columbia River Basin. These include the U.S. Army Corps of Engineers (Corps), Bonneville Power Administration (BPA), National Marine Fisheries Service (NMFS), BOR, and U.S. Fish and Wildlife Service (USFWS). Additionally, several groups have formed specifically to study these issues:

- **The Northwest Power Planning Council (NPPC)** was formed in 1980 and is composed of representatives from Idaho, Montana, Oregon, and Washington. The NPPC is responsible for finding ways to acquire and market new power sources while giving equitable treatment to fish and wildlife. The NPPC issued the Columbia River Basin Fish and Wildlife Program in 1982. The program addresses salmon and steelhead production, safe passage, harvest management, resident fish and wildlife protection, future hydroelectric development, and coordination among Federal agencies responsible for Columbia River Basin resources. The NPPC makes annual funding recommendations to the BPA for projects to implement for protecting, mitigating, or enhancing fish and wildlife in the Columbia River Basin that have been negatively affected by hydroelectric dams.

- **The Snake River Salmon Recovery Team (SRSRT)** was appointed by NMFS to independently develop recommendations for a recovery plan for the Snake River sockeye and chinook salmon. NMFS used these recommendations in the development of the recovery plan issued in 1995.

- **The Independent Scientific Group (ISG)** was funded by BPA to conduct a biennial review of the science underlying salmon and steelhead recovery efforts. The ISG issued a 1996 report that provides a scientific foundation for public policy to be developed by NPPC.

- **The Analytical Coordination Work Group (ANCOOR)** consists of fishery modelers from NMFS, BPA, NPPC, the Corps, states, and tribes. The objective of this group is to compare and enhance smolt passage survival and lifecycle models used within the region. ANCOOR was formed in 1993.

Several environmental impact statements (EISs) and related documents have been developed by the Corps in the 1990s, with the BPA, BOR, or NMFS as cooperating agencies:

- The Columbia River Salmon Flow Measures Options Analysis EIS (OA/EIS) (issued in 1992) evaluated the effects of operational changes at certain Federal multipurpose water projects in the FCRPS. The Corps also prepared a biological assessment (BA) of whether the proposed actions would jeopardize listed species. NMFS reviewed this information and issued a biological opinion that the proposed operations were not likely to jeopardize the existence of listed or proposed salmon species. The Corps then issued a Record of Decision (ROD) that described its Operations Plan for 1992.

- The Interim Columbia and Snake Rivers Flow Improvement Measures for Salmon Final Supplemental Environmental Impact Statement (SEIS) was prepared by the Corps in 1993. It addressed issues similar to the 1992 EIS, but evaluated effects of actions occurring over a longer period of time and included some projects not addressed in the 1992 OA/EIS. The preferred alternative recommended some changes to the 1992 Operating Plan. Included in the alternatives was a biological drawdown test of Lower Granite Dam on the lower Snake River. A companion EIS was developed specifically for a series of biological drawdown tests, but was never completed because juvenile salmon were shown to have a high survival rate (over 90 percent) through the dam.

- The System Configuration Study (SCS) was initiated by the Corps in 1991 to evaluate the technical, environmental, and economic effects of potential modifications to the configuration of Federal dams and reservoirs. The Lower Snake River Juvenile Salmon Migration Feasibility Study, described in this EIS, is one of several studies conducted under this program. This study was initiated in 1994 to specifically evaluate the technical, environmental, social, and economic effects of potential modification to four projects on the lower Snake River. Additional studies are evaluating other projects on the Columbia and Snake Rivers.
- The Columbia River System Operation Review (SOR) was initiated in 1990 by the Corps, BPA, and BOR to review multipurpose management of the Columbia-Snake River System and provide a strategy for system operation. The final EIS was issued in 1995.
- NMFS issued two more biological opinions on operations of the Columbia River System: the 1993 biological opinion was based on 1993 operations, and the 1994 biological opinion was based on operations from 1994 through 1999. Again, both opinions ultimately indicated that operations were not likely to jeopardize the continued existence of the endangered or threatened Snake River salmon. After the 1993 opinion was challenged and overturned in the courts, NMFS issued a new opinion in 1995 indicating that operations were likely to jeopardize the salmon and that long-term system reconfigurations were necessary. The NMFS 1995 Biological Opinion also included an alternative to the proposed action of the 1993 EIS; this alternative requested that the Corps evaluate one of three drawdown scenarios and implement surface collectors. In 1995, the Corps issued a ROD that stated its intentions to follow through with NMFS' recommendations as quickly as possible.
- In May 1998, NMFS issued the Supplemental FCRPS biological opinion. This opinion evaluated the effects of the configuration and operation of the FCRPS on newly listed threatened or endangered steelhead in the Columbia River, Snake River, and lower Columbia River. Other supplemental opinions were issued in 1999 and 2000. For both of these, the long-term decision-making process was unchanged from that set forth in the 1995 biological opinion.
- In December 1999, the Corps, BPA, and BOR issued a BA of the entire FCRPS. This BA was prepared in response to the decision-making process established in the 1995 biological opinion.
- In December 2000, two biological opinions were issued in response to the 1999 BA. One was prepared by NMFS and addressed anadromous species in the Columbia River Basin. The second was issued by USFWS and focused on bull trout in the FCRPS and Kootenai River sturgeon. The Corps, BPA, and BOR are currently reviewing the two opinions and are preparing an implementation plan.

1. Introduction

The U.S. Army Corps of Engineers' (Corps) Lower Snake River Juvenile Salmon Migration Feasibility Study (the current study) was initiated in 1994 to evaluate the technical, environmental, social, and economic effects of potential modifications to the configuration (structural components and their arrangement) of four Federal facilities (Ice Harbor, Lower Monumental, Little Goose, Lower Granite) on the lower Snake River. The intent of these modifications is to increase the survival of juvenile anadromous fish as they migrate through the Lower Snake River Hydropower Project.

The current study is not an isolated project. It is one part of a large, multiyear, multiagency effort to restore salmon stocks in the Federal Columbia River Power System (FCRPS). The Corps is playing a significant role in this effort, along with the Bonneville Power Administration (BPA), the Bureau of Reclamation (BOR), the National Marine Fisheries Service (NMFS), and the U.S. Fish and Wildlife Service (USFWS). To understand the purpose, role, and goals of this specific study, it is helpful to understand the general historical and technical context. In addition to the Federal agencies listed above that have a direct responsibility for the FCRPS, other Federal agencies such as the Environmental Protection Agency (EPA) and USDA Forest Service have also influenced Federal policy in the Columbia River Basin and are important for recovery of listed salmon species. Also, state agencies from Washington, Oregon, Idaho, and Montana; industry; academia; and citizens have influenced the management of salmon and steelhead species that are the focus of the current study.

The following sections are provided to give historical context to the current study. Section 2 is a synopsis of public and management perspectives since the mid-19th century and examines the development and changes in hydropower, habitat, hatcheries, and harvest. It also explores changes in how the public perception of "conservation" has changed over that period. Section 3 provides a summarization of significant events and documents from 1990 to the present related to salmon restoration efforts in the FCRPS. The most significant events and documents are highlighted on Figure 1-1.

Figure 1-1. Chronology of Significant Salmon Recovery-related Events and Documents Since 1990

1990

- **April** — Petition submitted to list Snake River sockeye as endangered under ESA
- **June** — Petition submitted to list Snake River spring/summer and fall chinook as threatened under ESA
- **July** — Columbia River SOR initiated
- **October** — Salmon Summit begins

1991

- **November** — Snake River sockeye listed as endangered under ESA
- **December** — NPPC, Phase II Amendments to Fish and Wildlife Program completed and issued

1992

- **January** — Columbia River Salmon Flow Measures OA/EIS issued
- **March** — Corps conducts drawdown test of Lower Granite and Little Goose reservoirs
- **April** — Snake River spring/summer and fall chinook listed as threatened under ESA
- **February** — Corps issues ROD to implement drawdown test of Lower Granite and Little Goose reservoirs
- **March** — System Configuration Study, Phase I initiated
- **April** — NMFS issues “no jeopardy” Biological Opinion on Proposed 1992 Operations of FCRPS
- **April** — Corps issues ROD on Proposed 1992 Operations of the FCRPS

1993

- **March** — Interim Columbia and Snake Rivers Flow Improvement Measures for Salmon Supplemental EIS issued
- **May** — NMFS issues “no jeopardy” Biological Opinion on Proposed 1993 Operations of the FCRPS
- **June** — Corps issues ROD on Proposed 1993 Operations of the FCRPS
- **December** — ESA critical habitat for Snake River sockeye, spring/summer chinook, and fall chinook designated
- **Throughout Year** — Formation of regional forums to begin providing input into salmon processes (i.e., PATH)

Figure 1-1. Chronology of Significant Salmon Recovery-related Events and Documents Since 1990 (continued)

1994

March
NMFS issues "no jeopardy" Biological Opinion on Proposed 1994 to 1999 Operations of the FCRPS

April
Federal District Court sets aside NMFS' Biological Opinion on Proposed 1993 Operations of FCRPS and the Corps and BoR RODs, and orders preparation of new Biological Opinion and RODs

August
NMFS issues a proposed rule to list spring/summer chinook and fall chinook as endangered but later (1998) withdraws it, leaving the stocks listed as threatened

April
Lower Snake River Biological Drawdown Test Draft EIS issued

May
Snake River Salmon Recovery Team issues final recommendations to NMFS

November
Lower Snake River Juvenile Salmon Migration Feasibility Study initiated as part of the System Configuration Study, Phase II

1995

March
NMFS issues new Biological Opinion on 1995 to 1998 Operation of FCRPS, finding jeopardy to listed salmon stocks and recommending "Reasonable and Prudent Alternatives"

March
Corps issues ROD on FCRPS Operations for 1995 and future years

March
NMFS issues Proposed Recovery Plan for Snake River salmon

November
Final EIS for the Columbia River SOR issued

1996

August
Snake River wild steelhead proposed for threatened listing under ESA

September
Independent Scientific Group review of NPPC's Fish and Wildlife Program issued

December
Lower Snake River Juvenile Salmon Migration Feasibility Study, Interim Status Report issued

Figure 1-1. Chronology of Significant Salmon Recovery-related Events and Documents Since 1990 (continued)

1997

August — Snake River steelhead listed as threatened; Upper Columbia River steelhead listed as endangered

1998

March — Lower Columbia River steelhead listed as endangered

May — NMFS issues 1998 Supplemental FCRPS Biological Opinion on steelhead listed in August 1997

November — NPPC Multi-species Framework Project initiated

November — Oregon voters approve the Oregon Plan

1999

March — Upper Colombia River spring chinook listed as endangered; Upper Willamette chinook, Lower Columbia River chinook, Middle Columbia River steelhead, Upper Willamette River steelhead, and Columbia River chum listed (all) as threatened

September — Washington releases the Statewide Strategy to Salmon Recovery, "Extinction is Not a Option"

December — Supplemental Biological Opinion Issued on flow augmentation and operation of BOR projects above Lower Granite

December — Corps, BPA, and BOR issue BA on FCRPS

December — Federal Caucus releases the "All-H Paper"

December — Corps releases Draft Lower Snake Juvenile Salmon Migration Feasilbity Repor/Environmental Impact Statement

2000

February — Supplemental Biological Opinion issued on six species listed in March 1999

April — 2000 NPPL Columbia River fish and wildlife program

December — NMFS and USFWS issue separate Biological Opinions on operations of FCRPS

December — Federal Caucus releases "Final Basinwide Salmon Recovery Strategy"

2001

May — Corps issues Record of Consultation and Statement of Decision

2. Historical Perspectives

Attitudes toward the natural world have changed considerably over the last 150 years. If the Euroamericans who arrived on the Columbia and Snake Rivers during the mid-19th century could witness the debates regarding Pacific salmon in the 21st century, they might be astonished at the contrast in priorities and values. The first white settlers viewed salmon as an inexhaustible resource, and they devoted their energies to increasing the efficiency of harvest methods and transportation systems rather than considering the need to protect the region's fisheries.

By the late 19th century, far-sighted individuals had warned that some salmon species were headed for extinction, but their message was not widely heeded. The Federal government encouraged the perception that the nation could enjoy the fruits of development and continue to have fish too. Conservationists even advocated using the region's water, timber, and fisheries resources to the fullest extent. Not until the environmental era of the 1960s and 1970s did the region recognize the limitations of its resources, prompting dramatic changes in fisheries policy and management. Ideas leave their mark on land and water as surely as dams, logging trucks, and fish traps. The following sections describe the development of attitudes in the Pacific Northwest, providing historical background for the four primary contributors to salmon decline: hydroelectric development, habitat degradation, harvests, and hatcheries.

2.1 Hydroelectric Development

"Your power is turning our darkness to dawn,
So roll on, Columbia, roll on."
—Woody Guthrie

Few subjects are more controversial in the Pacific Northwest today than dams and their impacts on salmon. Public debate on this issue is widespread; major newspapers in Walla Walla, Portland, and Seattle have devoted considerable coverage to it during the last 30 years. These newspaper articles reveal a range of perceptions, from a view of dams as "river killers" to assertions that the problem of declining salmon is a great "hoax." Scientists, engineers, and policy-makers have long discussed the pros and cons of large multipurpose dam development on the Columbia and Snake Rivers. What has changed in recent years is the perception of urgency and the increased questioning of choices that the region made during the early and mid 20th century.

Many Americans welcomed the arrival of the first large multipurpose dams in the Columbia River Basin. No 20th-century development brought more economic benefits to the Pacific Northwest than the hydroelectric projects along the Columbia and Snake Rivers. The Federal government funded the construction of large multipurpose dams on the lower Columbia and Snake Rivers, as these projects remained beyond the financial reach of individuals and small companies. During the late 1920s, Congress authorized extensive surveys of the region's waterways, compiling information on stream flows, topography, hydrography, irrigable lands, and flood-prone areas. These surveys led to a comprehensive plan for developing the Columbia Basin's water resources. Beginning with Bonneville Dam, completed in 1938, the large multipurpose projects in this region created jobs and the promise of future development. Dams provided flood control and improvements in navigation, along with irrigation for farmers cultivating the arid lands east of the Cascade Mountains.

The most important advantage provided by the dams was considered to be inexpensive power. Despite impending electrical rate hikes in 2001, the region's residents still enjoy the lowest rates in the nation. This trend began with the construction of multipurpose dams in the Columbia River Basin. Inexpensive public power brought electricity to thousands of people, while also attracting industries to the region. For example, aluminum businesses were established in the 1940s on the shores of the Columbia River, and the Boeing Company in Seattle looked to this industry for materials to build its planes. Historically, the Pacific Northwest had depended on logging, mining, farming, and fishing; however, the availability of inexpensive power diversified and expanded the region's economy. Without the dams along the Columbia and Snake Rivers, many residents would not live in this area today (Schwantes, 1996).

Many 20th-century Americans welcomed this development, regarding it as an advancement of civilization. Folk singer Woodie Guthrie, hired by the BPA, applauded the Federal construction of large dams on the Columbia, equating electricity with progress. He depicted the Columbia River dams as a metaphor for progress, a force that would turn "darkness to dawn." Before the dams, he explained, "all this here water" was "just a going to waste." To his mind, the Columbia "needs a couple more dozen big power dams scattered up and down it…keeping folks busy." Guthrie spoke for a generation of Americans awed by the size and complexity of the Columbia River dams, Grand Coulee in particular. This structure, according to Guthrie, "makes the Tower of Babel a plaything for a kid" (Dietrich, 1995). Guthrie's songs did not focus on the salmon runs that Grand Coulee blocked, or on the tribal and commercial fishers that relied on them.

The national conservation movement, which emerged during the late 19th and early 20th centuries, shared his view. Support for irrigation projects had been firmly rooted in the West since the early 20th century, with the passage of the Newlands Act in 1902 and the establishment of a Reclamation Service, which early conservationists promoted. They were concerned that the nation's resources be used wisely and efficiently. Rivers, they believed, should be controlled to produce the maximum benefit to humans. Conservation in the early 20th century focused on eliminating waste, not on protecting habitat. This attitude was reflected in a report that Congress considered in 1913, revealingly titled "Conservation of Natural Resources: An Article on the Waste of our Natural Resources Due to the Nondevelopment of our Water Powers."

By the 1920s and 1930s, this support had extended to generation of hydropower. Conservationists viewed the hydropower generation as an efficient use of water resources. Dams were in fact regarded as "conservation accomplishments." *Bird-Lore*, a national journal published by the Audubon Society, claimed in 1937 that Pacific Northwest residents "are eager for a larger population and more industries" (*Bird-Lore,* 1937).

During the 1930s, relatively few people objected to the construction of hydroelectric dams in the Columbia Basin. Some Americans disapproved of public power, condemning it as a socialist concept. The expense of reclamation projects in the remote West also drew protests. Fisheries scientists were among the most vehement objectors to large multipurpose projects. Worried that the dams would obstruct the migrations of salmon, the American Fisheries Society passed a resolution against high dams in 1941. Native Americans and commercial fishers also feared that the construction of large multipurpose projects would destroy salmon runs (Palmer, 1991).

While some Americans dismissed these protests as doomsaying, the Federal government did incorporate fisheries management and protection of salmon into water resources development work. In its attempt to accommodate a myriad of interests, Congress concluded that the nation could have dams and fish, too. As *The Oregonian* reported during the 1940s, Federal officials remained convinced that "you can have both dams and salmon" (*The Oregonian,* 1945 and 1947). This perception persisted into the late 20th century, when a Washington State Department of Ecology official assured readers of *The Seattle Times* that the nation can produce power "while still assuring the reasonable maintenance of fisheries resources" (*The Seattle Times,* 1971).

To ensure the continuation of salmon runs, the Federal government funded research and construction of fish passage facilities on the lower Columbia and Snake Rivers. From the beginning of its construction of large multipurpose dams on the Columbia River, the Corps recognized the need to improve fish passage facilities. Beginning with Bonneville Dam in the 1930s, fisheries scientists worked with engineers to refine these facilities. The first challenge that they faced was the lack of information on fish passage. The Baker River Project in the North Cascades, constructed in the mid-1920s, had been one of the projects to confront this issue. "There is no precedent of a problem as it exists at Baker in handling fish," explained one official of the Puget Sound Power & Light Company in 1929, "so it has been a matter of cut-and-try." Fisheries scientists and engineers would also use the "cut-and-try" approach in the Columbia River Basin for the next several decades (Mighetto, 2000).

The fish collection and bypass system at Bonneville included three reinforced concrete fish ladders and two pairs of fish lifts. The fish ladders resembled a stairway of 40-foot-wide compartments, each one foot higher than the last. Engineers built one ladder at each end of the spillway dam and one at the north end of the powerhouse, enabling the fish to ascend 70 feet to the pool behind the dam. The Corps placed lifts at the north end of the spillway dam and at the south end of the powerhouse. These structures operated on the principle of a navigation lock and were designed to accommodate 30,000 fish per day. Also noteworthy was the dam's fish collection system. Fisheries experts recommended that the Corps construct a collection system that included "extensive and varied" entrances supplied with constant water velocity at a high volume. During the first 30 years of operation, an average of one million fish annually passed through this system. Its cost reached nearly $7 million, representing approximately 15 percent of the project cost (Mighetto and Ebel, 1994).

An article in *Colliers* pronounced the fishways at Bonneville "the most unique stairways and elevators of all time." Similarly, *Scientific American* described the construction of fishways as a pioneering effort. This "immense experiment," the journal reported in 1938, "is undoubtedly the greatest thing of its kind reared anywhere up to date. The success of these fishways is a matter of world-wide interest." Initially, the fish passage system at Bonneville appeared so successful that it served as a model for subsequent dams on the Columbia and Snake Rivers. Promoters of further dam development pointed to the success of the Bonneville fish passage system to demonstrate that dams and salmon could co-exist. In 1938, Willis H. Rich, Director of Research for the Fish Commission, pronounced the operation of the ladders "entirely successful" (Mighetto and Ebel, 1994).

Early fish passage facilities focused on assisting adult salmon migrating upstream. Later studies at Bonneville and other dams, however, revealed a mortality rate of at least 15 percent for downstream migrating juvenile salmon at each dam. From 1938 to 1975, the Corps and public and private utility companies constructed 15 additional dams on the Columbia and Snake Rivers. During these decades, it became apparent that adult fish passage structures would not be sufficient to offset the effects of hydroelectric development in the Columbia River Basin. Fisheries managers devoted increasing energy to researching and constructing facilities to augment the survival rate of juvenile salmon.

Public perceptions of hydroelectric development changed considerably during these decades as well. When Congress authorized the Snake River dams in 1945, many Americans viewed hydropower and improved navigation along the Snake River as vital to national defense. Opposition to the dams appeared almost immediately as fisheries experts, tribal fishers, sportfishermen, and commercial fishermen worried that additional development in the Columbia River Basin would further deplete salmon runs. For 10 years, these groups fought the dams, testifying at public hearings about the need for more fisheries research and improvements in fish passage. The Federal government, balancing a variety of interests, continued to support dams, while also making certain that they included fish passage facilities. The Interior Department summarized the Federal position in 1947 as follows: "the Government's efforts should be directed toward ameliorating the impact of this development upon the injured interests and not toward a vain attempt to hold still the hands of the clock" (Petersen and Reed, 1992).

Accordingly, construction of the dams proceeded, with Ice Harbor Dam completed in 1961. President Lyndon B. Johnson dedicated this structure on May 10, 1962 and his words revealed continued support for the dams and what they represented. "All great civilizations have drawn their strength from the valleys of great rivers," he told the crowd. "While America reaches toward the stars, while our aspirations and achievements alike soar to new heights…let us never cease to build in these valleys" (*The Oregonian,* 1962). The completion of Ice Harbor Dam was followed by Lower Monumental Dam in 1969, Little Goose Dam in 1970, and Lower Granite Dam in 1975 (Peterson and Reed, 1992).

These projects included some of the most technically sophisticated fish passage systems in the world. Even so, salmon, particularly juvenile fish, were impaired by this construction. They were injured passing the turbines, their migrations slowed, and they became more vulnerable to predators behind the dams. The problem of gas supersaturation at spillways was particularly serious, resulting in fish kills during the early 1970s, which were widely reported by media throughout the Pacific Northwest and the nation. The *Walla Walla Union Bulletin*, for example, described a legislative hearing in Spokane in 1971. "Don't you think your dam building is going to kill these fish?" asked one state senator of the Corps. In response, Gordon Fernald, Chief Engineer for the North Pacific Division, assured him that the nitrogen problem "is of great concern to us and has our No. 1 priority" (*Walla Walla Union Bulletin,* 1971).

The environmental movement of the 1970s helped fuel public concern about the negative affects of dams on salmon. This decade witnessed a profound transformation in values and attitudes toward the natural world. While early conservationists had focused on the need to use natural resources wisely, encouraging technological solutions, the new movement sprang from a growing awareness of the importance of biodiversity and ecosystems and preferred "natural," non-structural solutions. This increasing environmental awareness, set against the historical backdrop of the push for and benefits of progress, set the stage for the current public debate over hydroelectric dams.

2.2 Habitat

> "Garbage was always a problem around the cannery and the mess house… All the garbage from the mess house was tossed over the fence into the creek… If anyone asked what to do with any kind of debris, he was told to just throw it into the creek. Twice a year the creek in flood or high water from the Columbia would sweep away all the debris."
>
> —Francis Seufert

As a cause of salmon decline, "habitat" is especially complex in terms of historical attitudes and practices. "Habitat" is a modern concept; newspapers and other popular publications rarely used the term until the 1960s and 1970s. During the 19th century, settlers in the Columbia River Basin did not view their surroundings as a "habitat" or as an ecosystem. Many Euroamericans perceived natural resources, including salmon and timber, as disparate commodities to be harvested and used. Moreover, changes to habitat were sometimes incremental and difficult to detect. When advocates for salmon searched for causes of the decline of the region's fisheries, they tended to focus on visible, easily identified causes such as harvests and dams.

In the course of their life cycle, salmon utilize a wide variety of aquatic systems including rivers, streams, wetlands, estuaries, and the open sea. Over the course of the last several centuries, human activities have disturbed and altered large portions of this habitat. Mining, logging, farming, grazing, urbanization, and industrial pollution have all taken their toll on aquatic habitat used by salmon populations in the Columbia and Snake Rivers. The building of dams has also eliminated a good deal of salmon habitat. While each of these endeavors has a long history, their pace and intensity increased dramatically over the past 100 years, contributing significantly to the ESA listing several species of Columbia and Snake River salmon.

2.2.1 Mining

Mining, which had become a significant industry by the mid-19th century, affected salmon habitat in a variety of ways. As biologist Henry Ward noted, this activity amounted to a "violent overturning of natural soil" (Taylor, 1999). Many mining operations occurred a few feet from the water, and detritus washed into streams, smothering spawning beds. Soil was not the only thing washing into the streams; gold and coal mining caused acidic chemicals to leach into streams, altering their chemical balance. Large-scale industrial mining in the Columbia Basin produced large piles of tailings that in subsequent decades would release heavy metals, especially lead, into tributary streams (Robbins, 1996; Netboy, 1980; Dietrich, 1995).

Mining also relied on a series of mechanical operations that caused additional harm to streams. Diversion dams rarely included fishways, and both juvenile and adult salmon were drawn into ditches and blown through nozzles. Salmon that remained in the stream often experienced decreased water levels in the summer months. This drop in water often contributed to a rise in water temperature, threatening salmon further. Miners also used wing dams to divert streams temporarily and some streams were blocked entirely. By the end of the 19th century, miners also began using dredges to root through streambeds at a faster and more destructive pace (Taylor, 1999).

Placer mining for gold was particularly destructive. This process, in which the stream's gravel was washed to find gold, destroyed spawning and rearing areas, tore up the stream bed, and flushed silt and debris into the stream. Not only did it damage salmon habitat, it also contributed to a decline in water quality. Many observers recognized the negative impact of mining on salmon habitat. In fact, as early as 1894, the U.S. Fish Commission reported that placer mining near Caldwell, Idaho had significantly reduced salmon runs on the upper Boise River (Gilbert and Evermann, 1894). By the 1940s, large sections of the Burnt, Grande Ronde, and Clearwater Rivers were judged "unsuitable for salmon" (Taylor, 1999). Despite this recognition, many forms of mining continue today in the Columbia Basin and throughout the Pacific Northwest.

2.2.2 Logging

Logging, which grew to be one of the most important industries in the Pacific Northwest, also affected salmon habitat in numerous ways. Logging was relatively small and localized in the Columbia Basin until 1894, when the new railroads cut shipping rates to spur business. By 1909 there were 300 lumber mills in the mountains that fringe the Columbia Plateau, and logging volumes in northern Idaho had increased 14 times over (Dietrich, 1995).

In the early days of the timber industry, loggers cut primarily along riparian areas and nearby hillsides. They also relied on the network of waterways to float their timber to the mills and markets that lay downstream. This activity reduced streamside cover, destabilized stream banks, and increased sediment loads. Dragging large trees up and down steep slopes to yarding sites, or directly into the river, disturbed soils, contributing to increased surface erosion. Once the trees reached the water's edge, logs often jammed in streams, sometimes preventing salmon passage. In an attempt to regulate streamflow and avoid these types of jams, loggers constructed splash dams along many of the area's rivers. These dams allowed loggers to retain water and then flush logs downstream on a precise schedule. The dams also helped extend operations into the dry season.

Loggers began using splash dams in coastal streams as early as 1870, and the practice continued in some places through the 1930s (Taylor, 1999). These structures caused serious problems for salmon. Many of them completely blocked the stream or river, and very few included effective fishways. Splash dams also caused the water flow to fluctuate wildly. When the dam gates were closed, streams dried up. Once the dams were opened, the stream was flooded in a torrent of churning water. This sudden rush of water and logs scoured spawning beds and rechanneled streams, harming salmon, eggs, and juveniles caught in the flood. Huge releases of water also eroded riverbanks, widened streambeds, and buried the deep pools salmon needed for migration and rearing (Taylor, 1999).

While cutting along riparian areas was the easiest method for early loggers, eventually these areas were depleted and logging moved upslope into the interior timber stands. The pace of logging quickened in the first half of the 20th century. The advent of railroads and, later, logging trucks and road networks, aided the process of transporting these logs to market, and removed some of the industry's reliance on waterways. The introduction of steam power to logging operations, especially in the form of the steam donkey, increased the efficiency harvest. High-lead yarding, saw blades, and chain saws, were also introduced during this period. These changes allowed the industry to cut deeper and faster into forests, exacerbating problems with erosion, siltation, and logjams (Robbins, 1996; Taylor, 1999).

2.2.3 Agriculture

In addition to mining and logging, the development of agriculture over the past century affected numerous streams in the Columbia River Basin. Farming, which was an integral component of pioneer life in the region, accelerated considerably with the advent of railroads, and the new markets they promised. By the late 19th century, the trade in agricultural goods was booming, and crops such as wheat stretched across the Columbia River Basin.

Historical farming practices affected salmon habitat in many ways. Plowing, for example, released large amounts of sediments into nearby rivers and streams, making fish migration more difficult and reducing the quality of spawning and rearing areas. The more farmers tilled the soil, the greater the sediment loads became in the streams. By the 1880s, heavy silt loads had become noticeable in the Columbia River Basin. Plowing also released pesticides and fertilizers that were used to control crops (Taylor, 1999). In addition, the use of herbicides and pesticides has been raised as a potential impact that has contributed to the decline of salmon.

Agricultural practices in coastal areas also affected habitat. Farmers in estuarine communities diked and dredged hundreds of acres of wetlands in order to plant their crops and graze their livestock. Wetlands, however, were "the grocery store of the wild," providing crucial feeding grounds for salmon as they made their journey from inland streams to the ocean (Dietrich, 1995). Without this chance to feed, salmon entered the Pacific poorly nourished and less equipped for their ocean migration. Today, in the lowest 46 miles of the Columbia, only 23 percent of tidal swamps and 35 percent of marsh swamps remain (Dietrich, 1995).

Farming in the arid areas of the Pacific Northwest further altered the region's land and water resources. Beginning in the 19th century, many farmers in the Columbia River Basin transformed arid lands through irrigation. Commercial irrigation began in the 1860s and 1870s, providing opportunities to farm more areas east of the Cascades. The arrival of railroads boosted irrigation attempts as farmers attempted to increase production lured by the possibility of new foreign and domestic markets (Taylor, 1999).

Increased irrigation, however, meant a decrease in salmon. The most obvious effect of irrigation was the diversion of water from streams. This often occurred when water was needed for upstream or downstream migrations, and, in many cases, entire streams were left completely dry. The building of diversion canals and small dams for agricultural production further hindered the migration of salmon. The canals, many of which were left unscreened, stranded salmon on farm fields, where they died (Mighetto and Ebel, 1994; Netboy, 1980; Taylor, 1999). Today, there are more than 900 irrigation intake structures in Washington, Oregon, and Idaho; only in recent years has there been a systematic effort to get them screened. There is no maintenance program, however, to keep them that way (Dietrich, 1995). Small dams for irrigation led to further problems. Most farmers used simple gravity systems with headgates, but some employed low dams to divert water. While a few of these dams extended only partly into the current, most spanned entire streams and none had fishways. During high water fish could pass these barriers, but in periods of low water, fish passage was prevented (Taylor, 1999).

Early settlers were aware of the potentially destructive nature of these small dams. In 1848, the constitution for Oregon Territory declared that rivers and streams important for anadromous fish "shall not be obstructed by dams or otherwise, unless such dams or obstructions are so constructed as to allow salmon to pass freely up and down such rivers and streams." In 1894 Hugh M. Smith of the U.S. Fish Commission argued that one dam on the Clackamas River in Oregon "is generally recognized as one of the greatest evils now affecting the fisheries of the Columbia River Basin" (Mighetto and Ebel, 1994). Despite their concern, many dams continued to block fish passage and destroy habitat.

The agricultural industry's effect on the land was not limited to the planting of crops and the procurement of water. Many ranchers grazed sheep, goats, and cattle. Dairy herds predominated in the wetter climates of western Oregon, while cattle and sheep dominated the plateau. As they foraged for food and water, livestock altered streamside vegetation, affecting salmon habitat. Away from the streams, they destroyed ground cover. Runoff increased in winter and spring, causing downcutting of riverbeds and banks, but then dropped dangerously low in the summer, leaving some spawning beds dry. Near the streams, livestock stripped protective vegetative cover from the banks, crumbled dirt into the rivers, and defecated in the water. As historian Joseph Taylor noted, "Cattle demonstrated a particular talent for turning streams into bovine toilets" (Taylor, 1999).

2.2.4 Industrialization

The impact of mining, logging, farming, and grazing on salmon habitat was compounded by industrial pollution that flowed into the Columbia and its tributaries. Untreated industrial wastes together with urban sewage severely degraded water quality and breeding habitat. Pollutants and urban sewage became especially serious in the post World War II era, when industrial activity expanded and the population grew. Pulp and paper mills, many of which were located along the Willamette River in Oregon, poured enormous quantities of wood chips and chemicals into the river, as well as released fumes into the air. Drawn to a waterfront location, other industries, such as canneries and smelters, joined the pulp and paper manufacturers on the Columbia and its tributaries (Netboy, 1980; Robbins, 1996). Describing the dumping practices of a salmon cannery, cannery owner Francis Seufert recalled that, "All garbage from the mess house was tossed over the fence into the creek." He continued, "If anyone asked what to do with any kind of debris, he was told to just throw it into the creek. Twice a year the creek in flood or high water from the Columbia would sweep away all the debris" (Dietrich, 1995). Mine tailings also contributed to the chemicals that leached into the region's waterways.

In addition to industrial pollutants, rivers and streams in the Columbia watershed became affected by urban and rural communities' practice of releasing untreated sewage directly into open waters. As the region's population expanded, the problem of urban sewage became more ominous. Near Portland, the Willamette River became so polluted that during the summer there was not enough oxygen to support fish life. "Even crawfish crawled out of the water to get some air," remarked one observer (Netboy, 1980). Communities along the lower Columbia also treated it as an open sewer, much to the dismay of gillnetters who often found their nets "shrouded with slime" (Netboy, 1980).

These activities did not go unnoticed. As early as 1933, for example, the Oregon State Game Commission stated that "there is no question but that the pollution of the tributaries of the Columbia is a menace to the salmon industry" (Mighetto and Ebel, 1994). In 1942, the National Resources Planning Board warned that the "pollution of waters in a number of areas of the Pacific Northwest [is] a growing menace quite generally, the cities and industrial plants discharge raw sewage into streams" (Dietrich, 1995). Today, while public outcry and government regulations have resulted in the treatment of certain industrial wastes, many chemicals continue to enter the Columbia and its tributaries, threatening salmon and other aquatic life.

2.3 Harvests

"It was clear that too many fishermen were chasing too few fish."
Anthony Netboy, *The Columbia River Salmon and Steelhead Trout*, 1980.

2.3.1 Early Tribal Fishing

The rivers and streams of the Pacific Northwest were once thick with migrating salmon. Early visitors marveled at the spectacle, calling it "one of the striking wonders of the region" (Brown, 1982). In the mid-19th century, salmon were viewed as an inexhaustible resource. The bounty of nature in the Pacific Northwest quickly became legendary, and many accounts by Euroamerican observers suggested that this resource could last forever, much like the ancient forests that stretched across the Northwest or the buffalo that inhabited the Great Plains. So abundant were the salmon runs that one English visitor wrote that, "the number of fish who reached these beds was so great the receding waters would leave millions of dead salmon strewn along the banks, emitting a stench that could be smelled miles off, and which never failed to attract a great number of bears." He continued, "Though I have never performed the feat of walking across a stream on the backs of fish, which many an old timer will swear he has done, I have certainly seen fish so numerous near their spawning grounds that nowhere could you have thrown a stone into the water without hitting a salmon." Confronted with an astonishing number of spawned out and dying salmon as he searched for a spot to beach his boat, artist Paul Kane similarly observed, "I have been obliged to travel through a while at night trying to find an encampment which would be free from their disgusting effluvia" (Dietrich, 1995).


Native American Dipnet Fishery Site at Celilio Falls

Native Americans had long relied on Columbia River Salmon. Anthony Netboy, who wrote extensively on salmon issues in the mid-20th century, argued that the "cycle of salmon and other anadromous fish appearing and disappearing from the rivers ruled the rhythm of Indian life, for without a fish supply they were in danger of starving." To maximize their catch, Indians tended to concentrate their fishing at natural barriers, such as waterfalls, which held up migratory fish. At these sites, Native peoples erected platforms from which they used dipnets to capture fish. Salmon were also caught in bays and sloughs with spears, harpoons, dipnets, hook and line, and, on a larger scale, with seines, traps, and weirs. Indians sometimes fished from canoes, using bone hooks and lines to which smelt were attached as bait. Salmon, sturgeon, and other large fish could be stabbed with a gig or a spear. On a communal level, Indians commonly erected weirs, which were constructed of brush and saplings and supported by willow stakes to which baskets were attached. These structures were most successful in narrow channels (Netboy, 1980).

Indian dipnet sites were more than simply a place to catch fish. They were also intimately known and personal spaces. Tommy Thompson, the 80-year-old leader of Celilio Village wrote in 1945, "All these usual custom fishing places and rocks have names and I know all of them." These sites were repositories of individual and tribal memory, places where generations had come together to celebrate the arrival of the salmon, and, as such, they were valued possessions. The Bonneville Dam destroyed the Indian dipnet fishery at the Cascades in the late 1930s, Grand Coulee drowned the one at Kettle Falls in the early 1940s, and the Dalles Dam flooded the last remaining Columbia dipnet fishery at Celilio Falls in 1956 (White, 1995).

2.3.2 Early Commercial Fishing

While Indians were the first people to utilize the salmon of the Columbia River, the abundance of this fish soon attracted others. The earliest commercial ventures on the river were the canneries, which were established in the mid-19th century along the Pacific Coast. William Hume at Eagle Cliff established the first cannery on the Columbia in 1866. In its first year of operation, the cannery released a pack of 6,000 cases of 48 cans each, for a total value of $64,000 (Schwantes, 1996). From its inception as a single factory, canning quickly became a full-fledged industry on the Columbia River. By 1873, there were eight canneries, and 10 years later there were 39. The period from 1883 to 1887 marked the peak in the number of canneries on the Columbia; shortly thereafter, the number of factories dropped off rapidly. By 1890 there were 21, and by 1935 only 10 canneries were left (Craig and Hacker, 1940).

For a brief period, however, the industry boomed. One reason for the rapid development of canning was that it was "an entirely new industry with an apparently inexhaustible supply of the raw materials ready at hand and easily obtained" (Craig and Hacker, 1940). Chinook salmon, which sometimes weighed more than 100 pounds and were referred to as "June hogs," were one of the most popular "raw materials" for cannery owners. One cannery owner was particularly impressed with this fish. "Because of their size, when you packed them into cans, only one slice of salmon was necessary to fill the can. When the customer purchased this can of Royal Chinook salmon and took it home and emptied it, he found just one nice chunk of salmon the size of the can, rich in oil, fine color, excellent texture, and superb flavor." He concluded that, "This salmon really deserved to be called Royal Chinook. It had no peer in the canned salmon markets of the world" (Dietrich, 1995).

In addition to the abundant supply of fish, the industry was also aided by good prices and quick profits from moderate investments (Craig and Hacker, 1940). Canned salmon was popular in both the United States and abroad as inexpensive, nourishing working-class food (Schwantes, 1996). During the early years of the industry, the principal markets were South America, China, and the Hawaiian Islands. California also received a good deal of canned salmon from the Columbia River. By 1874, limited shipments of canned salmon were being sent to New York, St. Louis, Chicago, Memphis, and New Orleans. The domestic market expanded with the construction of railroads, which linked the Pacific Coast to the eastern United States and Europe (Craig and Hacker, 1940).

Given its auspicious start, it is perhaps surprising how quickly this industry declined. Part of the reason was that, as the number of plants exploded and production increased, prices began to drop. Competition from cheaper fish, such as steelhead and salmon from other districts, also lowered prices. In addition, as the number of establishments grew, the canneries competed with one another for fish, raising the price they paid to the fishermen for the salmon. In 1878, canners paid fishermen $0.25 per chinook, by 1890 that price had increased to $1.00. During this same period, many packers also began to note that chinook runs were not as abundant as they once had been, and, fearing a shortage of fish, many left the business (Craig and Hacker, 1940). By the turn of the century, the canning industry was no longer centered on the Columbia River, as it expanded to Puget Sound and Alaska (Schwantes, 1996).

Commercial fishing ventures blossomed with the advent of the canning industry on the Columbia River. While chinook were the most popular fish among the canners, commercial anglers also caught coho, chum, and sockeye salmon. Another anadromous fish, steelhead trout, was also popular, and the Columbia River was in fact the principal steelhead stream on the Pacific Coast. In addition to migrating species, commercial fishermen also harvested shad, smelt, sturgeon, and crayfish from the Columbia River (Craig and Hacker, 1940).

Numerous methods were used to catch fish, both on the Columbia and its tributaries as well as on the open ocean. Some of the more widely used devices included gillnets, seines, diver nets, traps, pound nets, and fishwheels. Each of these methods was suited to specific places along a waterway, and each was uniquely constructed to ensnare unsuspecting fish.

Gillnets were favored in salmon harvesting along the Pacific Coast. Originally they were constructed of flax or linen twine, later replaced by nylon. These devices were hung along a rope with cork floats to support the upper portion of the net, while a line with lead sinkers kept the net vertical in the water. Often used in estuaries and rivers, their size varied depending on the depth of the water and the width of the fishing channel. When fish encountered a net, they were able to penetrate it partially, but as they tried to remove themselves their gills became entangled. The size of the opening varied, depending on the type of fish sought. Gillnets provided a highly efficient method of fishing, allowing smaller fish to swim unimpeded through the openings. When stretched across a river of migrating salmon, the net became heavy with entrapped fish in a matter of a few hours or even minutes (Cobb, 1930; Craig and Hacker, 1940; Roberge, 1985).

A number of types of seines were used on the Pacific Coast. Haul seines, for example, were prominent on the Columbia River. Haul seining occurred on sand bars at low tide. The net would be placed in a large seine boat that would circle around against the current until the net was paid out in the shape of a semicircle. There, a team of horses was hitched to it and would begin the process of hauling in the net (Cobb, 1930). Purse seines, which were used mostly in Puget Sound and southeast Alaska, were an effective technique for harvesting in deep waters. These large nets, which hung vertically in the water, were designed to be set between two boats surrounding a school of fish. They sometimes measured 3,000 feet in length and could reach depths of 80 feet. Purse seining was greatly aided in the early 20th century by the replacement of hand-powered vessels with motorboats. In 1934, 57 seines operated on the Columbia River, 33 on the Oregon side, and 24 on the Washington side (Craig and Hacker, 1940). These devices could catch tremendous numbers of fish. One seine, operated by the Seufert Brothers Company near Celilio Falls, harvested 70,000 pounds of fish on a single day in 1947 (Mighetto and Ebel, 1994).

Diver nets were used on the Columbia River, mainly on the upper and middle portions. These were used almost exclusively for chinook and consisted of two nets attached side by side. The outer one, which faced the oncoming fish, was of a larger mesh than the inner one. This helped ensure that if a fish was able to pass through the first net, it would be caught in the smaller openings of the second net (Cobb, 1930).

Fish traps or pound nets were also useful to fishermen on the Columbia River. These were stationary devices consisting of mesh webbing strung between posts driven into the river bottom. By featuring a lead, which guided salmon through a series of smaller and smaller openings until the fish were caught in a net, fish traps exploited salmon's tendency to swim upstream. Placed at the mouth of a river, these devices required little effort and could catch a considerable number of fish. By the late 1920s, fishers had more than 400 traps in the Columbia River region (Mighetto and Ebel, 1994).

Fish wheels first appeared on the Columbia in 1879. By the 20th century, there were approximately 79 of these devices operating along the river. Essentially large wooden water wheels, these structures were built over rocky channels where migrating salmon tended to swim. As the current turned the wheel, a wooden bucket on the downstream side of the paddle would scoop up salmon, lift them clear of the river, and dump them into a deep wooden box. While the wheels only took about 5 percent of the Columbia salmon harvest, historian William Dietrich argued that "their looming presence and the inexorable turn of their wheel seemed like an irritating reminder of the insatiable and shortsighted greed that ruled the fishing industry." Eventually the wheels were banned in Oregon in 1926 and Washington in 1934 (Dietrich, 1995).

Devices such as the fish wheel and purse seine took their toll on salmon populations. Chinook, which was the most sought after of the salmon species, was the first to show signs of decline. The number of chinook salmon peaked in the 1880s, and as early as 1894, the Oregon Fish and Game Protector warned that chinook populations were "threatened with annihilation." As the number of chinook fell, fishermen moved on to other species, such as coho and sockeye. These fish were also marked by a "pronounced fall" by the early 1920s (Mighetto and Ebel, 1994). The decline was truly staggering. In 1911, 46 million pounds of canned Columbia salmon were produced. In 1938, the year the Bonneville Dam was completed, the annual catch of salmon had slumped to 20 million pounds (Dietrich, 1995).

Concern for the deteriorating fishing industry sparked a series of conservation measures. While other factors, such as habitat decline surely contributed to the demise of salmon runs, overfishing was an obvious culprit and an easy target for conservationists. These early attempts were, however, sporadic and largely ineffective. As early as 1877, the legislature of Washington established a closed season; Oregon followed quickly with similar measures. State governments also banned the use of certain types of fishing gear on the Columbia River. For example, during the late 19th century, Oregon and Washington prohibited fish traps, weirs, and seines. Purse seines were prohibited on the Columbia in 1917 and by 1922 they were also banned in the coastal waters off Oregon and Washington. As noted previously, fishwheels had been banned in 1926 and 1934. Although both Oregon and Washington created fish commissions in the 1880s and 1890s, neither organization had sufficient funds to police the river and catch offenders. Thus, these early restrictions did little to halt declining salmon runs (Mighetto and Ebel, 1994).

Economic concerns promoted these early conservation measures. In the 1930s, W.H. Rich, Director of Research for the Oregon Fish Commissioner, argued that salmon were worthy of "consideration far beyond their immediate economic value." His pleas were largely ignored, and the fishery issue continued to be framed as a technical problem in a largely economic enterprise. Managers, canners, and commercial fishermen defined salmon as "capital," regarding these fish as a commodity, similar to lumber or wheat (White, 1995). In this era, when many managers and policy makers unquestioningly placed their faith in the ability of science and technology to protect natural resources, the hope was that the "resource [salmon] can be preserved if proper planning and conservation measures are followed" (Craig and Hacker, 1940).

During the late 19th and early 20th centuries, concern about sustaining the salmon runs was related to anxiety about extensive harvests of other resources, including timber. Some Americans at this time viewed the widespread, unrestricted logging in western Washington with alarm, fearing that the timber would be depleted. This desire to protect the country's natural resources from unregulated use resulted in the formation of a nationwide conservation movement. Advocates promoted establishment of forest reserves (later called national forests) such as the area set aside around Mount Baker in 1897. These were public lands that the Federal government managed.

Conservationists also called for protection of fish and wildlife, which they viewed as public resources. Late 19th-century Americans had witnessed harvests of unprecedented proportions. Many attributed the rapid decline of the buffalo and passenger pigeon to hunting for profit. These species were once so abundant that they seemed inexhaustible. By the 1870s and 1880s, however, the buffalo had become nearly extinct, and the last passenger pigeon, a prolific species whose extensive flocks had once darkened the skies of the Midwest and the eastern United States, died in the Cincinnati zoo in 1914 (Reiger, 1986).

During this era, some observers feared that the salmon were headed for a similar fate. Encouraged by conservationists, Federal and state governments created fisheries agencies during the late 19th and early 20th centuries to ensure perpetuation of fish populations—particularly those with high values for commercial and sport catches. Although habitat degradation also led to fish loss, it was sometimes more difficult to detect and less immediately visible than salmon harvesting. Accordingly, early efforts to protect salmon and steelhead focused on managing harvests rather than protecting habitat. The objective was to decrease the number of fish taken by implementing regulations.

Despite their belief in the powers of science and technology, early conservationists were hampered by a lack of understanding of the river conditions and habitat requirements of anadromous fish. Also, there was little knowledge about the actual migration cycle of salmon. In 1888, the Corps reported that "almost nothing" was known about where the salmon travel, "how they fare, or what motives guide their course in their mysterious ocean sojourns." In the 20th century, planners continually complained about the "meager and fragmentary data" available on the habits of fish, and in 1909 the Bureau of Fisheries remarked that this topic was "shrouded in obscurity" (Mighetto and Ebel, 1994).

2.3.3 Early Sport Fishing

As scientists and managers directed their conservation efforts towards the commercial fishing industry, they largely overlooked another important group who also harvested Columbia River salmon—recreational anglers. During the late 19th century, the Columbia River became world renowned for recreational fishing. Like the canners, sportfishermen were especially interested in chinook, which afforded the "best sport." Sockeye and steelhead were also popular catches. Anglers estimated the worth of a species based on its "character," which was comprised of its preference of bait, fighting ability, and taste. "Those that passed muster were lionized," according to historian Joseph Taylor, while "those that failed were labeled 'coarse' or 'rough.'" (Taylor, 1999).

To catch any manner of fish, anglers used a variety of baits. Visiting sportsmen from the east preferred to use flies to catch the prized chinook, while local anglers used salmon roe and spoons or fishing lures. These were spoon-shaped devices with a treble barbed hook that could cause serious injury to the fish when removed. Each group debated about the merits of its favored technique.

Early limits on the catching of salmon for personal use were liberal. In 1922, an attempt in Washington to restrict the catch to 3 salmon, 18 inches or greater in length, was so poorly received by anglers that within the year the limit was increased to 25 salmon, 10 inches or more in length. While catch limits were unpopular among many sportfishermen, early sports fishing organizations in Oregon and Washington did attempt to implement protective measures. One of the earliest was the Steelhead Trout Club of Washington, which was formed in 1928 to monitor catches of net-scarred fish (nets had become illegal by this time) and encourage greater protection of steelhead. The Washington State Game and Fish Protective Association advocated the implementation of uniform game laws, including bag limits. In Oregon, the Sportsman's League was established in 1913 to serve as a clearinghouse organization for state sport groups. In 1919, the League submitted two initiatives to the public, one that would create a separate game commission and the other that would establish local control over fish propagation and the taking of fish from streams (Mighetto and Ebel, 1994).

2.3.4 Tribal Fishing in Modern Era

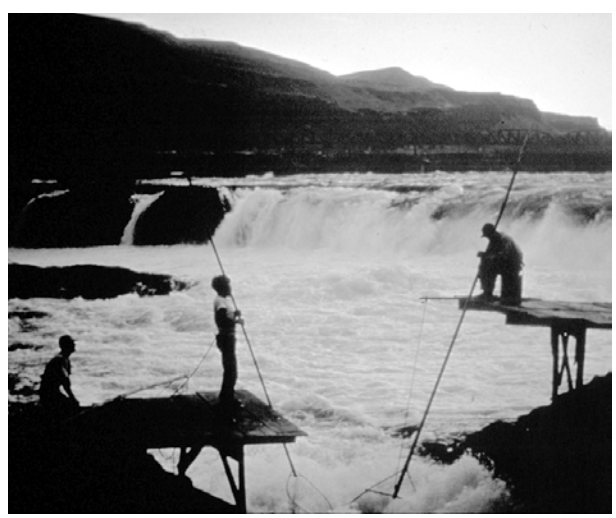
As the number of anglers on the Columbia River increased, the number of fish declined. While it was easy to blame fishers for this decrease in salmon, harvests were only one factor contributing to the rapidly vanishing fisheries. Habitat loss and degradation, coupled with the rise of multipurpose dams, also took a heavy toll on salmon populations. Nevertheless, overharvesting remained a problem, and increased pressure on the resource led to increased conflict among user groups.

Tension between Native American fishers and other users of the Columbia River was not a new phenomenon, but rather dates back to the 1850s. During the 20th century, however, conflicts escalated as tribes asserted their rights to continue fishing, at times turning to the courts. One of the earliest litigation cases, involving Indian fishers in the Northwest was in 1905 and addressed the question of access to off-reservation fishing sites. In *U.S. v. Winans,* the U.S. Supreme Court ruled that the Indians retained the right of access to their "usual and accustomed" fishing places. In 1919, the Court reaffirmed this decision in *Suefert Brothers Company v. U.S.* (Smith, 1979).

The construction of large multipurpose dams along the Columbia River, beginning in the 1930s, prompted further questions about treaty rights, and many Indians protested individual dam projects. In *Tulee v. Washington*, a Federal court recognized in 1942 that prior to negotiation of the treaties, the tribes had established fishing regulations "through custom and tradition." The Federal courts in the 1940s and 1950s suggested that in the interest of conservation the states should also limit the taking of fish; however, the issue was not clarified. Accordingly, throughout the 1960s, Indians in the Northwest argued that the conservation regulations of fisheries agencies were discriminatory in their attempts to limit salmon catches outside the reservation. By the mid 1960s, protests had become militant. To bring the issue to public attention, some Indians organized "fish-ins," which were deliberate attempts to get arrested for catching salmon illegally (Landau, 1980).

Two crucial rulings affecting Indian fishing rights were made in the 1960s and 1970s. The first was *U.S. v. Oregon*, in which a group of Northwest Indians, the Sohappy plaintiffs, argued that their subjection to state fishing regulations violated their 1855 treaty rights. In 1969, Judge Robert Belloni ruled that the state must give Native Americans the opportunity to harvest "a fair and equitable share of fish which the state permits to be taken from any given run." The second case, which unfolded in Washington, addressed the issue of inequitable harvesting and whether Indians were subject to state regulations off the reservation. In this case, Judge George Boldt interpreted the 1855 treaty phrase "in common" to suggest equal sharing among non-Indian and Native American fishers. "In common with," he concluded, "means sharing equally the opportunity to take fish at 'usual and accustomed grounds and stations.'" Treaty Indians were therefore entitled to 50 percent of the harvestable catch not needed for spawning escapement. Shortly after Boldt's ruling, Judge Belloni also adopted the 50 percent allocation for Oregon, and in 1979, the Supreme Court upheld the Boldt decision (Landau, 1980).

These court decisions did not end the debate over Native American fishing. To implement the court decisions in Washington and Oregon, state governments had to increase the Indian harvest of salmon by decreasing the catch of other fishers. Not surprisingly, this was not always well received. Sportfishermen, for example, protested Native Americans capturing steelhead in their nets. Steelhead, which had been declared a game fish in both states, could only be taken with hook and line. To conserve this fish, state agencies also established limits on gear, bag, size, and duration of season. The Indian treaties, however, had not distinguished between food and game fish, and sportsmen resented Boldt's decision to allow Indians to sell steelhead. But for Indians, steelhead were economically as well as culturally significant (Smith, 1979).



By the late 1980s and 1990s, relations between Indians and other anglers had improved. Both groups had gained a greater recognition of the limitations of the fisheries, and the need to cooperate to find a solution. It had become clear that in-fighting among commercial, sport, and tribal fishermen would not save the salmon.

2.3.5 Commercial and Sport Fishing in Modern Era

During the 20th century, commercial catches of salmon and steelhead on the Columbia River varied. In the late 1930s, they averaged about 18 million pounds annually, which was a substantial drop from the 40 million pounds averaged during World War I and a decline of 50 percent from their 1911 peak. Catches dropped steadily in the post World War II era (Netboy, 1980; White, 1995). During the 1940s, ocean trollers hauled a large percentage of the catch, and advances in technology improved navigational aids, netting materials, and fish-hauling equipment.

Salmon were in fact viewed as an important resource during World War II. "Columbia River chinook salmon is recognized as the best," asserted one U.S. Army bulletin. "It is exceptionally rich in oil and of a delicious flavor. The flesh is very tender." *The Oregonian* further informed its readers in 1945 "weary soldiers have been fortified by Columbia River salmon strips on a piece of hardtack. When they want food with plenty of nutrition, military organizations all the way from the U.S. Army to the Royal Canadian Mounted Police specify Columbia River chinook salmon." Housewives also appreciated this fish, viewing it as a delicacy. "Few…have not sighed over flaky steaks and tempting slabs from the oven, garnished with lemon and browned butter" (*The Oregonian,* 1945).

The 1940s also saw an increase in regulations. The Pacific Marine Fisheries Commission, for example, was established in 1947 to oversee ocean fisheries along the West Coast. This interstate commission reviewed fisheries research data and tried to develop unified positions on regional fisheries issues. In later decades, fishing seasons were shortened and the number of fishing fleets was restricted (Mighetto and Ebel, 1994).

After World War II, population growth as well as increased affluence and leisure time considerably augmented the number of recreational anglers. The interest in sports fishing grew rapidly in the 1960s and 1970s. Almost a million anglers fished for salmon and steelhead in the rivers in 1976 and 1977 in Oregon, Washington, and Idaho. In 1976, their coho catch was 1,720,000, and in 1977, a drought year, it was 900,000. Sportfisherman chinook harvest totaled 631,000 in 1976 and 553,000 in 1977, while the steelhead catch increased from 210,000 to 258,000. Anthony Netboy painted a vivid picture of the scene that must have greeted sportfishermen during this period. "On any summer morning, especially on weekends," he wrote, "in towns [located on both sides of the Columbia], there is a stir and bustle long before the sun rises in the eastern sky. Boats are tied up side by side on the slippery docks…by sunrise the entire fleet is beginning to head for the Columbia bar and soon myriads are converging on the area where the fish are known to be moving. Fishing lines are dangling from the sides or afterdecks, the boats, with their engines stopped, rising and falling with the swells. Over their radios skippers are communicating in staccato tones, telling each other where fish are being caught, and racing their boats and anglers to the spots" (Netboy, 1980).

This activity, like the activities of large multipurpose dams along the Columbia and Snake Rivers, remained highly visible to the public, resulting in calls for additional regulations. In the early 1960s, for example, Oregon imposed a limit of two salmon, 22 inches or more in length for the mouth of the Columbia River. Washington allowed a daily bag of three fish, 20 inches or more. Fish derbies, which were once extremely popular tourist attractions along the Pacific Coast, were prohibited by the Oregon legislature in this period. In 1970, the sport-fishing season both on the ocean and in the rivers was reduced (Netboy, 1980). The following year, *The Seattle Times* reported the importance of not only protecting the salmon but also ensuring that the various uses, including sport fishing, could continue. "Tens of thousands of salmon and steelhead are caught by sportsmen" in the Columbia River Basin, noted one biologist. "Ask the hundreds of thousands of people who participate or are affected in some way by this activity if it is worth saving" (*The Seattle Times,* 1971).

2.4 Hatcheries

"In my mind, the use of hatcheries is going to continue to be a necessity…There's been too much degradation of habitat for wild runs, particularly in the main Columbia."
Bill Herschberger, Fish Geneticist, University of Washington

In addition to regulating seasons and methods of harvest, early state and Federal authorities turned to hatcheries and fish culture as a means to perpetuate salmon and steelhead populations. During the early 1870s, cannery interests in the Pacific Northwest experimented with artificial propagation of these fish, and for the next century the Oregon Fish Commission, Washington Department of Fisheries and Game, the U.S. Fish Commission, and their successor agencies constructed hatcheries throughout the Columbia River Basin and Puget Sound. Some fisheries authorities placed substantial faith in hatcheries. The U.S. Bureau of Fisheries, for example, claimed in 1913 "the possibilities for fish-cultural work are practically unlimited," particularly "with reference to the Pacific Coast salmon" (U.S. Bureau of Fisheries, 1913). Similarly, fisheries expert John N. Cobb noted in 1917 "the census of opinion is that artificial culture does considerable good" (Cobb, 1917). This faith in hatcheries reflects an early 20th-century belief that science and technology combined could sustain a critical resource, allowing continued use and harvests (Taylor, 1999).

Most of the work in fish culture centered on the Columbia River. The Central Hatchery, established at Bonneville in 1909, was heralded as the largest in the world. By 1937, it had become one of seven hatcheries operated by the State of Oregon. The following year, the Mitchell Act funded state and Federal hatcheries on the lower Columbia River to offset the impacts of Bonneville and Grand Coulee Dams, along with the effects of logging and pollution. This legislation encouraged the establishment of hatcheries in Oregon, Washington, and Idaho (Mighetto and Ebel, 1994).

After World War II, engineers and fisheries managers continued to view hatcheries as the means to ensure continuing salmon runs. In 1976, Congress authorized construction or expansion of 12 hatcheries and 11 satellite facilities in Idaho, Oregon, and Washington at a cost of $177 million. These hatcheries were developed to mitigate the salmon losses resulting from the Snake River dams (U.S. Fish and Wildlife Service, 1990). During the 1960s through the 1980s, they helped increase the total number of salmon on the Columbia and Snake Rivers. Although some fisheries experts were skeptical, many viewed hatcheries as essential for sustaining salmon runs. Bill Herschberger, a fish geneticist at the University of Washington, explained "there's been too much degradation of habitat for wild runs" (Dietrich, 1995).

The region's earlier reliance on hatcheries, however, came under scrutiny during the environmental era. By the 1980s, an increasing number of fisheries biologists had pointed out that reliance on hatcheries had weakened the gene pools of wild stocks. Moreover, large numbers of juveniles released from hatcheries competed with wild salmon for food, space, and cover. Opponents of artificial propagation argued that wild fish remained genetically better equipped for survival, as hatchery fish are subject to disease and predation (Dietrich, 1995).

This change in thinking reflects a larger theme in fisheries management. Management practices, though based on science, are subject to change as public perceptions shift. During the early 20th century, for example, Cobb had argued that spawning fish should be removed from their streams—an action that was necessary for the operation of hatcheries. Because salmon die after spawning, he explained, natural reproduction left carcasses that clogged waterways, threatening the health of juvenile fish (Cobb, 1917). By the late 20th century, however, biologists had discovered that many wildlife species, including the bald eagle, depended on salmon carcasses. This became an observation that coincided with the weakening of support for hatcheries and artificial propagation. Some biologists now return the salmon carcasses from hatcheries to their streambeds.

Other fisheries management practices have come into question during the last 2 decades. Ideas about the role of large woody debris in stream channels, for instance, have also changed. As noted, early 20th-century logging operations gave little consideration to their effects on fish habitat, often piling logging slash and road construction debris into streambeds. During the 1960s and 1970s, fisheries managers overcompensated for this degradation by clearing streams so thoroughly that they became denuded of large woody debris. By the 1980s, fisheries biologists had discovered that this material, now often missing from streams, was crucial for anchoring the stream channel and gravel bars in streambeds.

While the problems with the region's fisheries had become evident during the 1980s, by the 1990s, the general decline of salmon runs had reached a critical point, which further called the reliance on hatcheries into question. In 1991, the Endangered Species Committee of the American Fisheries Society published its assessment on Pacific anadromous fish stocks outside of Alaska and the findings were disturbing. More than half of the stocks in Washington, Idaho, Oregon, and California were at risk of extinction, or were of "special concern." The report concluded that the region's management of fisheries was not working. The authors thus called for "a new paradigm that advances habitat restoration and ecosystem function rather than hatchery production" (Mighetto, 2000).

Subsequent events supported this dismal conclusion. Late in 1991, NMFS listed three stocks of salmon in the Snake River under the ESA. By the end of the decade, NMFS had listed nine additional salmon species in the Pacific Northwest, affecting the economies of Portland and Seattle as well as smaller communities in the region. Salmon decline was a highly visible, politicized issue that reflected a larger historical trend; the realization that the region's natural resources were limited. The perception of the Pacific Northwest as a place offering the wealth of nature's bounty in unlimited quantities had come to an end and scientists, economists, and policy makers were faced with the challenge of managing the resource in light of this fact. They were also faced with making decisions that affected increasingly diverse interests. Throughout the region's newspapers the words "balance" and "trade-off" appeared with increasing frequency, indicating that the future would bring difficult choices.

2.5 Environmental Movement

Underlying the changes in tribal, commercial, and recreational fisheries was a shifting perception of the role of salmon in the Pacific Northwest. The 1970s became a crucial decade in the story of the region's salmon and the various users. As the environmental movement took hold across the nation, it had a significant impact on natural resource issues in the region. Conservationists in the early part of the 20th century had focused on the need to use the country's natural resources wisely. Rather than seeking protection of natural areas such as forest and rivers, they wanted to use these resources in an efficient and sustainable manner. By the 1970s, however, arguments for protecting natural resources adopted a broader, more holistic, approach—one that would eventually look at ecosystems rather than individual species.

Several major forces encouraged the emergence of environmentalism. First, during the period of World War II, scientists had become concerned about radiation fallout, pesticides, and other contaminants that affected humans as well as fish and wildlife populations. The large variety and volume of hazardous substances released into our nation's land, water, and air alarmed the public. Second, the weakness in early fish and game policy, which had focused on attempts to restrict harvests and eliminate predators, became apparent during the mid to late 20th century. Finally, the environmental movement drew upon the counterculture's questioning of traditional values, including the assumption that natural resources were nothing more than economic commodities.

These new ideals were reflected in the activities of NMFS, charged with the protection of anadromous fish. The agency's mandate dates back more than a century. In 1871, Congress created the position of Commissioner of Fish and Fisheries within the United States Treasury Department. Initially, the commissioner's duties included reporting on the declining populations of food fishes in United States waters and recommending conservation measures. In 1903, Congress assimilated the commission into the newly created U.S. Bureau of Fisheries within the Department of Commerce and Labor. The Bureau of Fisheries remained there until 1939 when Franklin Roosevelt transferred them to the Department of Interior. The following year he combined the bureau with the Department of Agriculture's Biological Survey, thereby creating the USFWS. In 1970, Congress returned the Bureau of Commercial Fisheries to the Commerce Department, where it became known as the NMFS.

As noted, the management of the nation's fish has been viewed as an economic issue. By placing the agency responsible for salmon and other anadromous species in the Treasury Department and the Commerce Department, Congress indicated that fish were primarily valuable as a commodity, and that their contribution to our society was largely as economic capital. Salmon were viewed as being a crop that, with proper management and technological advancements, could produce high yields for human consumption. The concept of fish as crops was nothing new to foresters, whose primary agency (USDA Forest Service) was located in the Department of Agriculture. For decades the USDA Forest Service had advocated that timber production could best be managed on tree farms.

By the 1970s, NMFS, like other Federal agencies, had incorporated environmental ideals into its policy and management. The Endangered Species Act (ESA) of 1973 had established a set of regulations preventing the harvesting, possession, sale, and delivery of threatened and endangered species. It also required agencies such as NMFS to develop plans to recover animal populations listed as threatened or endangered. Few environmental statutes have wielded more impact than the ESA. Although Congress passed endangered species legislation in 1966 and 1969, the amended statute of 1973 proved to be one of the strongest statutes of the era. Its passage signaled that preventing extinction and protecting biodiversity had become major goals of natural resource policy at the national level.

The consequences of the ESA of 1973 proved to be especially far-reaching. The NMFS identified those species whose populations had dropped so low that they appeared likely to become endangered as "threatened," and those species that appeared in danger of becoming extinct as "endangered." Called the "pit bull of environmental law," the ESA established a set of regulations preventing the harvesting, possession, sale, and delivery of threatened and endangered species. It also required the appropriate agencies to develop a plan to recover animal populations listed as threatened or endangered. For the first time, natural resource managers in the public and private sectors had a Federal mandate to give high priority to endangered species and their habitat requirements. The variety of efforts, organizations, processes, and regulations concerned with present-day salmon recovery revolve around responding to and preventing ESA listing.

3. Significant Events and Documents Since 1990

This section summarizes significant events and documents related to the Corps' management of facilities on the lower Snake River since 1990, when the Salmon Summit was convened and the NMFS was first petitioned to list Snake River sockeye (*Oncorhynchus nerka*) as endangered under the ESA. The events and documents have been discussed, to the extent possible, in chronological order, although many significant activities have occurred simultaneously. Figure 1-1 summarizes key documents, EISs/EAs, or ESA listings since 1990 for Columbia River salmon and steelheads recovery planning efforts.

3.1 Salmon Summit

Senator Mark Hatfield of Oregon organized the Northwest Salmon Summit in Portland in 1990 to explore various ideas for fish protection (Mighetto and Ebel, 1994). Conducted before any Snake River salmon populations were listed under the ESA, the Summit intended to reach a consensus among Pacific Northwest interests and formulate a plan to address the problem of declining salmon stocks. In addition, participants were expected to suggest an appropriate response to NMFS' pending ESA listing of salmon. The Summit included the governors of Washington, Oregon, Idaho, and Montana, as well as 30 official members representing 28 organizations responsible for water management, power production or marketing, and fisheries management.

Participants divided into four separate task groups to study fish harvest, river flow, salmon production, and enforcement problems. The meetings began in October 1990 and continued into 1991. Although members developed various proposals, the divergent interests represented at the Summit did not reach an agreement on a fundamental approach to the problem. By the last formal meeting, held in early March 1991, Summit participants had not reached a consensus on a comprehensive plan of action or mitigation of impacts.

One of the most controversial proposals to emerge from the Summit was the idea of drawing down the reservoirs on the lower Snake River by as much as 30 meters (100 feet) or more (Mighetto and Ebel, 1994). Proponents believed that increased spill and water velocity during the spring migration would "flush" juvenile fish downstream, reducing their journey of approximately 30 days to 16 or 17 days. They believed that reduced migration time would increase survival by, among other things, decreasing the amount of time fish were exposed to predators. In 1991, it seemed that Summit participants reached an agreement for a one-year implementation plan. However, concern for adverse impacts of lowered water levels on shipping, port operation, recreation, and farming reduced the scope of actions agreed upon. Although the Salmon Summit failed to agree on a plan to save the salmon, the meetings contributed to the NMFS decision not to invoke an emergency listing for the sockeye salmon. Although the Summit's efforts did not prevent the ESA final listing, it did succeed in bringing a broad array of interests into recovery discussions. Participants, including the Corps, agreed to continue efforts to rebuild the depleted Columbia-Snake River system salmon stocks.

3.2 Endangered Species Act Listings for Northwest Salmon

On April 2, 1990, NMFS received a petition from the Shoshone Bannock Tribes of the Fort Hall Reservation, Idaho, to list Snake River sockeye as endangered under the ESA [Snake River Salmon

Recovery Team (SRSRT), 1994]. On June 7, 1990, NMFS received petitions from Oregon Trout, with co-petitioners Oregon Natural Resources Council, the Northwest Environmental Defense Center, American Rivers, and the Idaho and Oregon chapters of the American Fisheries Society to list Snake River spring chinook, Snake River summer chinook, and Snake River fall chinook (*O. tshawytscha*) under the ESA (SRSRT, 1994).

NMFS published notices on June 5, 1990 (55 Federal Register 22942) and September 11, 1990 (55 Federal Register 37342) stating that the petitions presented substantial scientific information indicating that the listings may be warranted (SRSRT, 1994). NMFS initiated a review of the status of each fish, and requested further biological information from the public. Status reviews for Snake River sockeye (Waples et al., 1991a), Snake River spring/summer chinook (Matthews and Waples, 1991), and Snake River fall chinook (Waples et al., 1991b) compiled the scientific information that led to the proposed listing of Snake River sockeye as endangered, and Snake River spring/summer chinook and Snake River fall chinook salmon as threatened (SRSRT, 1994).

Similar petitions and status reviews have been conducted for other groups of salmon or steelhead in the FCRPS. Overall, since 1991, 12 have been listed as follows:

- Snake River (SR) sockeye salmon (*O. nerka;* listed as endangered on November 20, 1991 [56 Federal Register 58619]); critical habitat designated on December 28, 1993 [58 Federal Register 68543]
- Snake River (SR) spring/summer chinook salmon (*Oncorhynchus tshawytscha;* listed as threatened on April 22, 1992 [57 FR 14653]); critical habitat designated on December 28, 1993 [58 Federal Register 68543], and revised on October 25, 1999 [64 Federal Register 57399]
- Snake River (SR) fall chinook salmon (*O. tshawytscha;* listed as threatened on April 22, 1992 [57 Federal Register 14653]); critical habitat designated on December 28, 1993 [58 Federal Register 68543]
- Snake River (SR) steelhead (*O. mykiss;* listed as threatened on August 18, 1997 ([62 Federal Register 43937]); critical habitat designated on February 16, 2000 [65 Federal Register 7764]
- Upper Columbia River (UCR) steelhead (*O. mykiss;* listed as endangered on August 18, 1997 [62 Federal Register 43937]); critical habitat designated on February 16, 2000 [65 Federal Register 7764]
- Lower Columbia River (LCR) steelhead (*O. mykiss;* listed as threatened on March 19, 1998 [63 Federal Register 13347]); critical habitat designated on February 16, 2000 [65 Federal Register 7764]
- Upper Willamette River (UWR) chinook salmon (*O. tshawytscha;* listed as endangered on March 24, 1999 [64 Federal Register 14308]); critical habitat designated on February 16, 2000 [65 Federal Register 7764]
- Upper Columbia River (UCR) spring chinook salmon (*O. tshawytscha;* listed as threatened on March 24, 1999 [64 Federal Register 14308]); critical habitat designated on February 16, 2000 [65 Federal Register 7764]

- Lower Columbia River (LCR) chinook salmon (*O. tshawytscha*; listed on March 24, 1999 (64 Federal Register 14308]); critical habitat designated on February 16, 2000 [65 FR 7764].
- Columbia River (CR) chum salmon (*O. keta;* listed as threatened on March 25, 1999 [64 Federal Register 14508]); critical habitat designated on February 16, 2000 [65 Federal Register 7764]
- Middle Columbia River (MCR) steelhead (*O. mykiss;* listed as threatened on March 25, 1999 [64 Federal Register 14517]); critical habitat designated on February 16, 2000 [65 Federal Register 7764]
- Upper Willamette River (UWR) steelhead (*O. mykiss;* listed as threatened on March 25, 1999 [64 Federal Register 14517]); critical habitat designated on February 16, 2000 [65 Federal Register 7764]

3.3 Northwest Power Planning Council Fish and Wildlife Program

The Northwest Power Planning Council (NPPC) was authorized by the Pacific Northwest Electric Planning and Conservation Act of 1980 (16 USC 839d-1). NPPC is made up of representatives from the states of Idaho, Montana, Oregon, and Washington and is entrusted with the responsibility of finding ways to acquire and market new power sources while giving equitable treatment to fish and wildlife. In 1982, the NPPC issued a comprehensive Columbia River Basin Fish and Wildlife Program (CRBFWP) that addressed salmon and steelhead production, safe passage, and harvest management; resident fish and wildlife protection; future hydroelectric development; and coordination among Federal agencies responsible for Columbia River Basin resources.

In 1991, the NPPC began a series of amendments to the Fish and Wildlife Program to institute a regional salmon and steelhead rebuilding plan. The NPPC was responding to a request from the Northwest Governors, the congressional delegation, and NMFS to develop a comprehensive salmon plan. All three entities had expressed interest in a regionally developed plan that NMFS could use as a basis for formulating its salmon recovery plan under the ESA. Although the focus of NPPC's efforts was the petitioned stocks, NPPC also believed that the measures it adopted would help all weak stocks. The purposes of the NPPC's amendments are to preserve the ecological and genetic diversity of the runs while rebuilding their overall numbers. In its efforts to produce a comprehensive plan, the NPPC considered all measures that could benefit salmon and steelhead, regardless of who should implement those measures (NPPC, 1991).

Phase I of the amendment process, which took place during the summer of 1991, focused on emergency habitat and production actions. Phase II amendments, completed in December 1991, concentrated primarily on fish survival during migration in the mainstems of the Columbia and Snake Rivers and on harvest. Phase II also introduced the concept of a framework that ties existing and future salmon rebuilding actions together into a comprehensive plan; the plan was based on stated goals and objectives, with performance standards and schedules to measure progress.

The NPPC currently makes annual funding recommendations to the BPA for projects to implement under the Fish and Wildlife Program. These projects are focused on protecting, mitigating, or enhancing fish and wildlife in the Columbia River Basin that have been impacted by hydroelectric dams.

Annex A contains excerpts from the amendments.

3.3.1 Independent Scientific Group Review of NPPC's Fish and Wildlife Program

In the December 1994 amendments to the CRBFWP, the NPPC called on the BPA to fund the Independent Scientific Group (ISG) to conduct a biennial review of the science underlying salmon and steelhead recovery efforts and Columbia River Basin ecosystem health. The NPPC's objective was to provide the region, to the greatest extent possible, clear analysis conducted by impartial experts.

The NPPC also asked that the ISG develop a conceptual foundation for the fish and wildlife program, to provide an overall set of scientific principles and assumptions on which the program and fish and wildlife management activities basinwide could be based and against which they could be evaluated. On September 18, 1996, the ISG delivered its report *Return to the River: Restoration of Salmonid Fishes in the Columbia River Ecosystem* to the NPPC (ISG, 1996). The report contains the first biennial review and a proposed conceptual foundation for the Fish and Wildlife Program. After an introductory chapter, the report is divided into four main components: Chapter 2 contains the proposed conceptual foundation for the Fish and Wildlife Program; Chapter 3 contains the review of scientific basis for measures included in the current Fish and Wildlife Program, using the conceptual foundation as a template for this evaluation; Chapters 4 through 10 contain the detailed technical data and documentation on which Chapters 2 and 3 are based; Chapter 11 describes general conclusions from the ISG review.

In submitting its report, the ISG expressed the hope that the report will be a valuable resource for decisionmakers. The findings should enable fishery managers to focus future research activities on areas that still are not thoroughly understood. However, the review does not include policy recommendations for recovery and restoration. Nor does it recommend specific measures or strategies or deal with institutional structures. It is not an implementation plan. Instead, the conceptual foundation proposed in the report should provide the scientific foundation for public policy to be developed by the NPPC and other decisionmaking bodies. It can be used to guide salmon restoration activities in general, as well as future development of the CRBFWP.

Annex A contains excerpts from the ISG Report (1996).

3.3.2 NPPC Multi-Species Framework

The ISG, in their report *Return to the River: Restoration of Salmonid Fishes in the Columbia River Ecosystem* (ISG, 1996) reviewed the NPPC's CRBFWP and criticized it for lacking a scientific foundation and vision for guiding the selection and implementation of projects. As a response, the Fish and Wildlife Program initiated the Multi-Species Framework Project in November 1998. The project sought input from individuals, state and Federal agencies, Indian tribes, environmental groups, and industry to develop alternative visions of the future Columbia River Basin and potential recovery actions for fish and wildlife in the basin. The potential actions ranged from flow modifications to dam breaching, acquisition and protection of habitat to expansion or reduction of hatcheries, and monitoring and research to passage barrier removal. The proposed actions were not limited to just those that the CRBFWP has authority to fund. Over 100 possible actions were proposed and from these, seven alternative visions were developed that included a specific suite of management actions. The visions for the basin ranged from a connected self-sustaining ecosystem with reduced power production, hatcheries, and in-river transportation (Alternative 1) to maximized economic production from river operations to finance habitat restoration and hatcheries (Alternative 7).

The alternatives were subsequently analyzed by a Human Effects Analysis Team and a custom implementation of Ecosystem Diagnosis and Treatment (EDT), an expert system that assessed the potential biological outcome from each alternative. No alternative was selected for implementation. Instead, the Multi-Species Framework process was used as a tool to help in the restructuring of the CRBFWP and development of the underlying framework and vision found lacking by the ISG.

3.3.3 Revised NPPC Columbia River Basin Fish and Wildlife Program

In early 2000, the NPPC re-initiated the process of amending the CRBFWP. Based upon the Independent Science Group review of the program and the Multi-Species Framework, a major revision of the CRBFWP evolved. An important revision to the program was inclusion of eight scientific principles and an overall vision to guide the program. In its broadest perspective, "The vision for this program is a Columbia River ecosystem that sustains an abundant, productive and diverse community of fish and wildlife, mitigating across the basin for the adverse effects to fish and wildlife caused by the development and operation of the hydrosystem and providing the benefits from fish and wildlife valued by the people of the region" (NPPC, 2000).

Based upon the strategy developed by the Federal Caucus (see Section 3.26), the CRBFWP assumes that dam breaching will not occur within the near future. The focus of the program is on fish and wildlife habitat through protection, restoration, and mitigation projects. However, the program also considers other types of projects including:

- Hydropower (flow management, fish transportation and passage)
- Data management
- Research, monitoring, and evaluation (including ocean conditions)
- Supplemental and production hatcheries (to replace lost habitat and extirpated populations).

Funding priorities for projects are to be based upon consistency with the overall vision, objectives, and strategy of the program and the specific biological objectives developed within individual subbasin plans. The biological objectives include both biological performance (abundance, capacity, productivity, and life history diversity) and the desired future environmental conditions. Although the NPPC has no authority over fishing regulations, the plans must also consider how harvest interacts with the biological objectives. Existing and proposed projects undergo a rolling 3-year review process by the Independent Scientific Review Panel (i.e., a third of the projects are reviewed each year).

3.4 System Configuration Study

The System Configuration Study (SCS) was initiated by the Corps in 1991 to evaluate the technical, environmental, and economic effects of potential modifications to the configuration of Federal dams and reservoirs on the Snake and Columbia Rivers with the goal of improving survival rates for anadromous salmonids migrating downriver (Corps, 1996). The SCS evolved in response to the NPPC's Fish and Wildlife Program Amendments (Phase Two) issued in December 1991 (Corps, 1996).

The SCS has been conducted in two separate phases (Corps, 1996). Phase I, a reconnaissance-level assessment of multiple concepts, including drawdown, upstream collection, additional reservoir storage, a migratory canal, and several other alternatives, was completed in June 1995 (Corps, 1996). Phase II is a detailed assessment of the alternatives that emerged from Phase I as holding the greatest potential benefit for anadromous salmonids (Corps, 1996).

3.4.1 SCS Phase I

Alternatives examined under Phase I, a reconnaissance-level screening of alternatives, included: 1) changes to existing facilities to improve passage and survival rates of juveniles and adults; 2) the possible addition of upstream water storage sites to be used for river flow and temperature modifications (the BOR is leading an interagency assessment of potential new dam sites); 3) annual drawdowns of four lower Snake and the John Day (lower Columbia) reservoirs to various levels during juvenile migration periods; and 4) the addition of new facilities, upstream of Lower Granite Dam, to collect juveniles and divert them onto a barge or into a migratory canal along the river, or a floating or underwater pressurized pipeline (in conjunction with Alternative 4).

The Corps initially had 22 options under Alternative 3 (above) pertaining to possible drawdowns of lower Snake facilities (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor). The initial screening, based on engineering feasibility, biological effectiveness [a Technical Advisory Group (TAG) assessed the biological impacts and effectiveness of alternatives being considered under Phase I; the TAG included representatives from the Corps and other Federal and state agencies, interest groups, and the biological community], and acceptability, eliminated 12 options. Additional screening narrowed the list to three drawdown options to be considered in greater detail in Phase II: 1) seasonal, near spillway crest drawdown; 2) seasonal, near natural river drawdown; and 3) permanent, near natural river drawdown.

3.4.2 SCS Phase II

SCS Phase II has developed into a major program containing many separate and specific studies (Corps, 1996). The Lower Snake River Juvenile Salmon Migration Feasibility Study is part of SCS Phase II, and is considered separately in Section 3.23. This growth in the scope of Phase II was considered necessary to adequately and efficiently respond to the requirements for multiple evaluations addressed in the NMFS 1995 Biological Opinion.

3.5 Columbia River Salmon Flow Measures Options Analysis/Environmental Impact Statement

In May 1991, the Corps, with BPA and BOR as cooperating agencies, began preparation of the 1992 Options Analysis/Environmental Impact Statement (OA/EIS) on the effects of operational changes at certain Federal multipurpose water projects in the FCRPS. The OA/EIS was undertaken to analyze effects of proposed changes to the FCRPS in response to several actions: the November 20, 1991 listing of the Snake River sockeye salmon as endangered under the ESA; the proposed listing of several other wild salmon stocks as endangered or threatened; discussions during the Salmon Summit; and recommendations contained in the Phase II amendments of NPPC's Fish and Wildlife Program. The final OA/EIS was issued in January 1992 (Corps, 1992).

The OA/EIS considered several alternative water management actions that could be taken in 1992 at dam and reservoir projects along the lower Snake and Columbia Rivers to improve juvenile and adult anadromous salmon migration conditions. Options considered were grouped into five general alternatives: 1) no action; 2) reservoir drawdown (including short-term tests); 3) flow augmentation; 4) combination of drawdown and flow augmentation; and 5) temperature control test. The action alternatives were designed to increase the velocity of the water, which in turn would pass the young salmon downstream faster during the April to August migration.

Several drawdown proposals were considered for all or part of the April to August migration, ranging from drawing down the reservoirs to the minimum normal operating level, to lowering the elevation of certain reservoirs to near the level of the overflow structure of the dam (spillway). The Corps identified eight options that fell within these drawdown ranges and also met operating considerations and flow velocity objectives. Six of the options applied to the lower Snake River facilities.

With flow augmentation, additional water would be released from storage reservoirs in the spring to increase the river flow during juvenile fish migration. Options considered varied with respect to the source of the water used to augment flows, the volume storage to be released, and the timing of releases. Based on computer analyses of combinations of options that provide significant increases in flow velocities, three combinations were identified as likely scenarios and were discussed in this OA/EIS. Release options were also considered to improve conditions for adult salmon migrating in the fall.

The environmental impacts of the proposed actions considered in the OA/EIS included the effects of altering normal river operations on a number of resource areas: water quality, anadromous fish, resident fish, wildlife, soils, air quality, transportation, agriculture, power, recreation, aesthetics, cultural resources, socioeconomics, and dam safety.

The preferred alternative for 1992 included: 1) drafting all four lower Snake River facilities to minimum operating pool (MOP) from April 1 to July 31; 2) conducting a drawdown test of Lower Granite and Little Goose in March; 3) operating the John Day reservoir at 80 meters (262.5 feet) (the minimum pool at which irrigation pumps will function) from May 1 through August 31, or until irrigation impacts are realized; 4) augmenting the lower Snake River flow with 111,060 hectare-meters (900 thousand acre-feet) or more from Dworkshak and variable releases to meet a target flow of 2,832 cubic meters per second (100 thousand cubic feet per second) at Lower Granite from April 15 through May 31; 5) augmenting the lower Columbia River flow up to 370,200 hectare-meters (3 million acre-feet) or less to meet target flow of 5,664 cubic meters per second (200 thousand cubic feet per second) at The Dalles from May 1 through June 30; and 6) releasing up to 44,424 hectare-meters (360 thousand acre-feet) from Dworshak in August to test temperature control options.

3.6 Reservoir Drawdown Test

As part of the 1992 Operation Plan, the Corps conducted a test drawdown at the Lower Granite and Little Goose facilities on the lower Snake River. The test was intended primarily to determine the physical effects of partial drawdown. As such, the test was scheduled to occur when few anadromous fish were present in the river. The idea behind the drawdown concept was to increase river velocities to more closely resemble natural juvenile migration conditions. In March 1992, the Corps drafted Lower Granite 11 meters (36 feet) and Little Goose 3.8 meters (12.5 feet) below the MOP levels for which they were designed. Nine spill tests were also conducted during the drawdown to determine impacts to structures, gas supersaturation levels from spilling, and potential adult passage conditions at these lower reservoir elevations.

Conclusions in the Corps' report (Corps, 1993a) on the drawdown experiment include:

- There was no major damage to dam facility structures and minor stilling basin damage.
- Turbines continued to operate safely, but efficiency decreased (potentially indicating increase in juvenile fish mortality); there was some vibration in the turbines.
- Water velocity measurements indicated that water velocities increased substantially in the upstream end of the reservoir as it returned to a near-natural river; in the lower reservoir, drawdown effects on velocity were considerably reduced in the deeper water near the dam.
- There was an increase in dissolved gas supersaturation in the stilling basin (which may result in gas bubble trauma in fish) during spill. Dissolved gas levels as a result of spills ranged up to 135 percent, from a background of 100 to 104 percent. The supersaturation level was related to total spill discharge.
- Some roads and railroad beds were damaged and embankment sloughs occurred in various areas along the reservoir.
- Large numbers of resident fish, clams, mussels, and crayfish were lost due to receding water elevations.

The test stopped commercial barge traffic and caused some damage to floating docks; structures located adjacent to or on rivers edge, well systems, irrigation systems, and recreation areas. Exposed cultural resources were mapped and documented during the test and precautions were taken to protect exposed artifacts.

3.7 NMFS Biological Opinion on Proposed 1992 Operations of the Federal Columbia River Power System

The listing of the Snake River sockeye as endangered under the ESA required the Corps to conduct formal consultations with NMFS on any action "authorized, funded, or carried out" by the Corps to ensure that said action "is not likely to jeopardize the continued existence of any endangered species or threatened species" (Section 7 of the ESA). Such consultation would involve the preparation of a biological assessment (BA) on the part of the Corps, and if necessary the issuance of a biological opinion by NMFS. The BA presents the Corps' assessment of whether or not the proposed actions would jeopardize the listed species, while the biological opinion is NMFS's opinion. A biological opinion is only required if the BA results in at least a "may affect, likely to adversely affect" determination.

Because the Snake River sockeye was listed as endangered in December 1991, consultation was added to the process of selecting the preferred river operation alternative in the 1992 OA/EIS. The consultation began on December 20, the day the ESA listing took effect. The Corps submitted a BA of actions proposed to increase velocities in Snake and Columbia River reservoirs as well as its draft Fish Passage Plan for 1992; BPA submitted a BA of the 1992 Operation of the FCRPS. NMFS reviewed this information, as well as modifications to the 1992 FCRPS Operations generated during the consultation process, and issued its required biological opinion on April 10, 1992 (NMFS, 1992). The biological opinion concluded, "that the proposed operations are not likely to jeopardize the continued existence of listed or proposed salmon species." However, in its transmittal letter NMFS included the caveat that it was "concerned that if operation of FCRPS continued as is proposed for

1992, it would not be sufficient to reverse the decline over one lifecycle of the salmon; therefore, additional steps will likely be needed in 1993 and future years."

3.8 Corps Operations Plan

After NMFS issued its biological opinion, the Corps issued a Record of Decision (ROD) that described its Operations Plan for 1992. The following measures were included in the Operations Plan:

- conduct a drawdown test at Lower Granite/Little Goose (addressed by a separate ROD issued in February 1992)
- operate lower Snake River facilities near MOP April 1 to July 31
- operate the John Day reservoir near 80 meters (262.5 feet) elevation from May 1 to August 31, unless impacts to irrigation intakes result
- conduct various flow augmentation releases from Dworshak Dam during salmon migration periods
- release water from Grand Coulee and Arrow Dams for flow augmentation from May 1 to June 30
- monitor and evaluate use of available water throughout the fish passage season
- continue release of additional water over spillways according to spill agreement
- continue fish transport
- continue improvements of fish passage systems.

3.9 Interim Columbia and Snake Rivers Flow Improvement Measures for Salmon Final Supplemental Environmental Impact Statement

The Interim Columbia and Snake Rivers Flow Improvement Measures for Salmon Final Supplemental Environmental Impact Statement (SEIS) evaluated the impacts of several alternatives for operating certain dams and reservoirs on the FCRPS during 1993 and future years until a long-term plan of action could be developed (based on results of ongoing long-term studies). The Corps in cooperation with BPA and BOR prepared the SEIS. The proposed action was being considered in response to the ESA listing for Snake River salmon. The SEIS was issued in March 1993 (Corps, 1993b).

The SEIS examined actions similar to those evaluated in the Columbia River Salmon Flow Measures OA/EIS (Corps, 1992), but as a recurring annual event over a longer time period. It also analyzed the impacts of such actions on projects not addressed in the OA/EIS. To conform to Council on Environmental Quality (CEQ) guidelines, the SEIS was "tiered" to the 1992 OA/EIS; this means that discussions and analyses from the OA/EIS, if there were no change, were generally summarized and incorporated by reference into the SEIS.

The SEIS addressed water management activities to be implemented in 1993 and planned for future years until the plan of action may be changed as a result of long-term studies. The actions considered in the SEIS involved some combination of measures similar to those selected in the 1992 OA/EIS and identified through consultation with NMFS under Section 7 of the ESA.

Specifically, the SEIS presented five alternatives:

1) A 1992 operation alternative without project conditions, or the no-action alternative, which represent water management actions undertaken from 1985 through 1990
2) A 1992 operation alternative excluding the March drawdown test of Lower Granite and Little Goose
3) The 1992 operation alternative (without the March drawdown test) modeled to display potential impacts to Libby and Hungry Horse under different operating assumptions
4) A modified 1992 operation alternative (without the March test drawdown), including improvement to salmon flows from Dworshak
5) The modified 1992 operation alternative (without the March test drawdown), modeled to show water from the upper Snake.

As with the 1992 OA/EIS, the environmental impacts of the proposed actions considered in this SEIS included the effects of altering normal river operations on a number of resource areas: water quality, anadromous fish, resident fish, wildlife, soils, air quality, transportation, agriculture, power, recreation, aesthetics, cultural resources, socioeconomics, and project structures.

The fourth alternative, involving modifications to the 1992-operating plan, was identified as the preferred alternative. It was selected on the basis of salmon survival effects, cost effectiveness, environmental effects, and the scope of existing authorities.

3.10 NMFS Biological Opinion on Proposed 1993 Operations of the FCRPS

On May 26, 1993, NMFS issued its biological opinion for 1993 operations of the FCRPS (NMFS, 1993). The biological opinion was based on a number of documents provided by the Corps, including the SEIS, as well as modifications to the 1993 Operations Plan developed during the intense consultation process. In the cover letter to the biological opinion, the NMFS Acting Assistant Administrator for Fisheries stated:

> *Operation of the FCRPS is a major factor in the decline of listed Snake River salmon. However, NMFS has determined that flow augmentation measures, adopted by the Federal agencies in the May 12, 1993 letter, and other measures including, spill improvement in structures and fish bypass facilities, and monitoring activities have reduced the anticipated mortality of listed Snake River salmon adequately for the purposes of the 1993 consultations to a level that is not likely to jeopardize the continued existence of the listed species. The Recovery Plan is expected to identify long-term, comprehensive, planning actions that will initiate the recovery of the listed Snake River salmon. Guidelines established by the Recovery Plan will be the basis for NMFS Section 7 consultations when the Plan is final.*

3.11 NMFS Biological Opinion on Proposed 1994 to 1999 Operation of the FCRPS and Juvenile Transportation Program in 1994 to 1998

This consultation concerned operations of the FCRPS from 1994 through January 31, 1999. NMFS considered a plan of actions for the FCRPS that the action agencies (Corps, BPA, BOR) proposed on December 2, 1993 in their BA and in revisions submitted in January 1994. NMFS issued its biological opinion on March 16, 1994 (NMFS, 1994). The biological opinion and the action agencies' RODs concluded that the proposed operation of the FCRPS was not likely to jeopardize the continued existence of the endangered or then threatened Snake River salmon species. The biological opinion included an incidental take statement pursuant to Section 7(a)(4) of the ESA which required that the action agencies comply with certain reasonable and prudent measure, terms, and conditions intended to further avoid and minimize take of listed salmon.

3.12 Litigation and Court Decision (*Idaho Department of Fish and Game v. National Marine Fisheries Service*)

At the same time the 1994 consultation was in progress, the Idaho Department of Fish and Game (IDFG), the state of Oregon, and four treaty tribes challenged the legal adequacy of NMFS' 1993 biological opinion for FCRPS Operations in Federal district court proceedings (*Idaho Department of Fish and Game v. National Marine Fisheries Service*, Civ. No. 92-973-MA (Lead Case), 93-1420-MA, 93-1603-MA, (D. Or.) (*IDFG v. NMFS*). In a judgment entered on April 28, 1994, the Court ordered on page 4 that:

> *IT IS FURTHER ORDERED AND ADJUDGED that the biological opinion on 1993 Federal Columbia River Power System operations prepared by the National Marine Fisheries Service, and the records of decision prepared by the Corps of Engineers and Bureau of Reclamation in reliance upon said biological opinion, for the reasons stated in this court's opinion of March 28, 1994, are arbitrary and capricious and otherwise not in accordance with the purposes of the Endangered Species Act, Section 7(a)(4), with respect to the chosen jeopardy standard and their consideration of reasonable and prudent alternatives to avoid jeopardy. That the 1993 biological opinion and records of decision are set aside and remanded to review and reconsider them, or at their option, to review and reconsider the 1994-98 hydropower biological opinion, in light of the (sic) court's order of March 28, 1994, and to submit a biological opinion and records of decision to address that ruling by June 27, 1994, unless that date is extended by further order of this court.*

NMFS and the action agencies, the defendants in this lawsuit, opted to reconsider the newly issued 1994 to 1998 FCRPS biological opinion rather than expend limited resources reconsidering the challenged 1993 opinion about FCRPS actions that were then completed. The Federal agencies further decided to work cooperatively with all the other parties, and particularly with the states and treaty tribes, rather than appealing the judgment and continuing to litigate the issues raised in the case.

From May 9, 1994, through November 30, 1994, NMFS and the action agencies (the Corps and BOR) participated in a series of discussions and working groups with the parties to this litigation. The purpose of these discussions was to better facilitate the collection and consideration of credible and relevant scientific evidence in a re-evaluation of the application of the standards of ESA Section

7(a)(2) to the FCRPS and of alternatives and measures for FCRPS operation and facilities. The Federal agencies and other parties to the litigation were aided by technical assistance provided through interagency working groups of technical personnel; one to consider the biological requirements of the listed species and the other to inventory and evaluate alternative actions and measures for the FCRPS.

The Court extended the original deadline established by the Judgment directing the issuance of a new biological opinion by January 30, 1995 (*IDFG v. NMFS*, Civil Minutes, Record of Order dated October 18, 1994: Granting Federal defendants October 8, 1994, request for extension of time as set forth in the schedule attached to William Stelle, Jr.'s affidavit). The Court granted further extensions in this deadline until March 1, 1995.

3.13 Snake River Salmon Recovery Team's Final Recommendations to the National Marine Fisheries Service

Following the listing of Snake River sockeye salmon as an endangered species, NMFS appointed the SRSRT to independently develop recommendations for a Recovery Plan for the species (as required under Section 4(f) of the ESA). Upon subsequent listings of Snake River spring/summer and fall chinook salmon as threatened species, SRSRT's responsibilities were expanded to include these fish as well (SRSRT, 1994).

The SRSRT developed draft recovery plan recommendations over the course of 27 months by compiling available information through an open public process. The SRSRT visited areas in the range (past and present distribution) of listed Snake River salmon and sought scientific, cultural, and economic expertise from parties throughout the region (SRSRT, 1994).

On October 20 1993, the SRSRT released draft recovery plan recommendations and solicited peer review to ensure that the factual materials were correct and that their analysis and interpretations were scientifically sound. SRSRT revised their recommendations based on comments received, updated information, and new analyses, and issued their final recommendations in May 1994.

3.14 Lower Snake River Biological Drawdown Test Draft Environmental Impact Statement

The Corps and NMFS as joint lead agencies, along with the BPA as a cooperating agency, analyzed four general alternatives intended to provide information on the biological effects of reservoir drawdown on migrating juvenile salmon and steelhead. The test would also provide an opportunity to study the effects of reservoir drawdown on adult salmonids, resident fish, wildlife, and other components of the lower Snake River ecosystem. These four alternatives included Alternative 1, No Action, and three different ways to conduct a biological drawdown test at the Lower Granite reservoir on the lower Snake River in Washington State. These action alternatives were: Alternative 2, using sanctuary dipnets or gatewell baskets to remove fish guided to the gatewell slots at the dam; Alternative 3, using a new gatewell tank removal system to bypass juvenile fish entering the powerhouse; and Alternative 4, using a new lower-level bypass system to divert fish entering the powerhouse.

The alternatives could have been implemented with the project spillway or the powerhouse as the primary route of downstream passage. The action alternatives had multiple options for spring, summer, or spring-summer test durations. The drawdown test could have been done for only one migration season, or could be repeated for up to 4 years. The preferred alternative of the agencies was Option 3A, a 2-month drawdown of the Lower Granite reservoir in spring 1996. However, findings from ongoing studies and data collection by scientists of the NMFS and the University of Washington School of Fisheries Center for Quantitative Science indicated that juvenile salmon migrating through the Lower Granite reservoir experienced a much higher survival rate than originally thought—in excess of 90 percent. Because juvenile salmon survival was shown to be already high through the reservoir, it was determined to be likely that there would be insufficient change resulting from a drawdown test at Lower Granite to make meaningful statistical inferences. Because of this, the drawdown test was never implemented, and no final EIS was prepared.

3.15 NMFS Biological Opinion on Reinitiation of Section 7 Consultation on Proposed 1994 to 1998 Operation of the FCRPS and Juvenile Transportation Program in 1995 and Future Years

With the conclusion of the 1994 lawsuit and associated post-judgment discussions, this consultation was formally reinitiated by the action agencies on December 15, 1994. In a letter to NMFS transmitting the Supplemental BA on Federal Columbia River Power Operations, the action agencies identified the proposed action under consideration to be the 1994 to 1998 operations proposed in the previous consultation while at the same time considering longer-term changes in operations and structures such as those identified in their System Operations Review (SOR).

On March 2, 1995, NMFS issued its biological opinion (NMFS, 1995a). The biological opinion concluded that "the operation of the FCRPS as described in the 1994 to 98 biological opinion is likely to jeopardize the continued existence of listed" salmon stocks (spring/summer chinook, fall chinook, sockeye). The biological opinion also concluded "the only way to achieve significant improvements is with long term system reconfigurations."

The biological opinion included a "Reasonable and Prudent Alternative to the Proposed Action" (alternative) which identifies "immediate, intermediate and long term actions that will improve the operation and configuration of the hydropower system" and will lead to reduced mortality of the listed fish. The biological opinion states the following:

> *The alternative employs an adaptive approach to increasing survival and the probability of recovery of listed salmon, by taking immediate actions to improve mainstem survival while reducing the uncertainty about the likely benefits of, need for and feasibility of major system structural modifications. Immediate survival improvements include improved bypasses, increased spills and spring/summer flows, reduced fish handling, better fish transportation conditions, etc. Major structural modifications include installation of surface collectors and drawdowns (natural river or spillway crest).*

The alternative identified six immediate planning and evaluation efforts to address potential system modifications, including "complete necessary planning tasks to begin implementation of drawdown." The alternative also specified a formal decision path for the implementation of long-term alternatives (Corps, 1996); the path has two major decision points. The first was in 1996, when the Corps was to have completed an interim evaluation report and preliminary decision regarding the selection of one of three drawdown alternatives (seasonal, near spillway crest drawdown; seasonal, near natural river drawdown; permanent, near natural river drawdown) and surface collectors (Corps, 1996). If a decision on drawdown could not be made in 1996, a second decision point was identified in 1999 (Corps, 1996). At that time, a final plan for drawdown or surface bypass collection would be selected, and feasibility evaluations and National Environmental Policy Act (NEPA) documentation would be completed (Corps, 1996).

3.16 Issuance of Corps' Record of Decision on Operations Plan for 1995 and Future Years

On March 10, 1995, the Corps issued its ROD on proposed operations of the FCRPS for 1995 and future years. The ROD documented the Corps' intent to fulfill the recommended measures in the NMFS Biological Opinion in an expeditious and responsive manner.

3.17 Supplements to the 1995 Biological Opinion

On May 14, 1998, NMFS issued the 1998 Supplemental FCRPS biological opinion. This ESA Section 7 consultation evaluated the effects of the configuration and operations of the FCRPS on newly listed threatened and endangered steelhead in the Upper Columbia River, Snake River, and Lower Columbia River ESUs.

In the 1998 Supplemental FCRPS biological opinion, NMFS determined that operating the FCRPS in accordance with the action agencies' proposed action, including the measures specified in the RPA of the 1995 FCRPS biological opinion (the 1995 RPA), would not jeopardize the continued existence of the newly listed steelhead. The 1998 Supplemental FCRPS biological opinion established spring flow objectives at Priest Rapids Dam to protect juvenile fish and expanded the spill program at many mainstem hydro projects, but otherwise left the decision-making process and timing for the long term as in the 1995 FCRPS biological opinion.

NMFS issued a second supplemental biological opinion on December 9, 1999. This biological opinion evaluated and documented BOR's planned operation to comply with the 1995 RPA prescription to deliver 427 thousand acre-feet (kaf) of upper Snake River water for flow augmentation and to review the operation of all BOR projects in the Snake River system above Lower Granite Dam. Again, the architecture of the long-term, decision-making process was unchanged from that set out in the 1995 RPA.

NMFS issued another supplemental biological opinion on February 4, 2000. That opinion considered the effects of FCRPS operations on six species that NMFS listed as threatened or endangered in March 1999. NMFS determined that the 1995 RPA, as modified by the 1998 proposed action and combined with a few additional interim measures, would not jeopardize the continued existence of any of the newly listed species for the rest of the interim period. The decision-making process and timing for the long term, again, remained consistent with the 1995 FCRPS biological opinion.

3.18 Action Agencies 1999 Biological Assessment

In December 1999, the action agencies issued a BA on the future operation of the entire FCRPS. This BA was developed to continue the consultation process initiated by the 1993 BA and to incorporate consideration on new listings made since that time and operational procedures for addressing potential impacts to juvenile migrants.

3.19 NMFS and USFWS 2000 Biological Opinions on Future Operation of the FCRPS

In December 2000, the NMFS and USFWS each issued biological opinions in response to the action agencies' 1999 BA on operation of the FCRPS. The USFWS biological opinion addressed bull trout in the FCRPS (listed under ESA as threatened) and Kootenai River White Sturgeon (listed under ESA as endangered).

The measures prescribed for Kootenai River White Sturgeon are focused on the operations of Libby and Hungry Horse Dams on the upper Columbia River. As a result, actions prescribed for Kootenai River White Sturgeon are not likely to affect the lower Snake River dams.

The FCRPS will be operated to meet objectives for Snake River Salmon Stocks, and Snake and Columbia River Steelhead Stocks. Measure to address bull trout are not specifically included in the operations for lower Snake River dams. In many cases, measures or actions for listed anadromous fish species may also address requirements for bull trout. Also, the USFWS has indicated that additional information is needed on the presence of, and use by, bull trout in the mainstem Snake River, including distribution, timing, and usage of the lower Snake River dams and reservoirs (USFWS, 2000).

The NMFS opinion addressed ESA-listed anadromous salmon or steelhead. The action agencies are currently reviewing both 2000 biological opinions and are developing an implementation plan in response to them.

In NMFS' 2000 biological opinion, operational and structural fish passage improvements at FCRPS projects were proposed to increase the survival of listed fish. The opinion presented specific hydropower measures that NMFS determined, based on the best scientific information, to be as follows:

- Biologically feasible and implementable
- Sufficient to achieve performance standards that represent the best the hydrosystem can do without dam breaching
- Sufficient to result in a high likelihood of survival and a moderate-to-high likelihood of recovery, combined with offsite mitigation measures and with other improvements affecting the listed species.

The hydrosystem measures are expected to reduce juvenile and adult salmonid mortality attributable to passage through the hydrosystem and to attain defined "performance standards" for recovery measures by 2010. The hydrosystem measures main features are described briefly below.

Proposed measures for improving water management so as to provide direct and indirect survival benefits to salmon include the following:

- Meet flow objectives at Lower Granite, Priest Rapids, McNary, and Bonneville Dams
- Provide in-season management for operational flexibility and best use of available water volumes
- Provide guidance on reservoir evaluations in early spring, early summer, and at the end of the summer flow augmentation season
- Coordinate with water release from Canada, the upper Snake River, and the Hells Canyon Complex
- Take specific actions to improve water management for salmon: 1) additional drafts of selected FCRPS reservoirs, 2) additional water from other sources, 3) shifts of flood control among projects, 4) implementation of flood control operations at the Libby and Hungry Horse reservoirs, 5) review of system flood control objectives, and 6) continued research on summer-migrating Snake River fall chinook salmon population losses.

The following actions are prescribed for improving juvenile passage survival through the FCRPS to the ocean:

- Increase spillway passage using gas abatement and longer spill hours to allow greater spill volumes; also, refine spill patterns and evaluate removable spillway weirs (RSWs) as ways of improving spill efficiency
- Conduct research on spillway passage to identify additional potential survival and passage improvements
- Increase screen/bypass system effectiveness with extended screens, new outfalls, and improved hydraulic conditions
- Develop and test surface bypass technology, with implementation as appropriate
- Provide improved turbine designs and operating guidelines
- Improve passage system operations and reliability.

Measures for improving juvenile reservoir survival, and thereby increasing the survival of downstream migrating salmon, include the following:

- Increase flow augmentation for summer migrants, particularly in the low water years
- Manage reservoir and run-of-river projects to reduce extreme water level fluctuations
- Manage predator populations (fishes, birds, and mammals).

Measures for improving adult survival are as follows:

- Develop actions to reduce fallback through turbines and over spillways
- Increase facility reliability and the ability to maintain operating criteria
- Investigate measures to protect steelhead kelts
- Investigate prespawning mortality.

Measures for improving water quality include the following:

- Make structural and operational modifications at spillways (e.g., spillway deflectors, improved spill patterns) to help reduce TDG levels
- Develop alternative fish passage measures (e.g., surface bypass)
- Release cool water from storage reservoirs (e.g., Dworshak Dam)
- Institute special powerhouse operations (e.g., McNary Dam).

NMFS proposed active investigation to reduce or resolve key uncertainties. Critical uncertainties relate primarily to the hypothesis of delayed mortality due to passage through the hydrosystem:

- Investigate delayed mortality of transported juvenile migrants (D-value when expressed relative to the survival of nontransported migrants below Bonneville Dam)
- Investigate delayed mortality of inriver juvenile migrants (extra mortality)
- Investigate delayed mortality or passage effects on adults
- Investigate estuarine/ocean survival.

3.20 A Proposed Recovery Plan for Snake River Salmon

In March 1995, NMFS published a Proposed Recovery Plan for Snake River Salmon, which aimed "to restore the health of the Columbia and Snake River ecosystem and to recover listed Salmon River stocks" (NMFS, 1995b). The proposed recovery plan was developed from recommendations made by the SRSRT in its May 1994 report to NMFS (SRSRT, 1994). The Recovery Plan includes the following:

> *The conservation of natural salmon and their habitat has not been afforded balanced consideration in past resource allocation decisions. Natural salmon are those that are the progeny of naturally spawning parents. Development in the Pacific Northwest has often proceeded with the assumption that improved technology or management would mitigate impacts on natural salmon stocks. The Region's reliance on uncertain mitigation schemes (as opposed to fundamental conservation strategies) has been a very costly approach, both for natural salmon and the public.*
>
> *However, recent efforts have concentrated on conserving natural salmon and their habitats. There is new emphasis being placed on natural fish escapement, improved migration conditions for juveniles and adults, increased riparian area protection, and equitable consideration of natural fish in resource allocation processes. This focus differs from previous management and represents important progress toward recovering listed Snake River salmon, restoring Columbia Basin ecosystem health, and benefiting other species presently in serious decline.*

Annex B contains a summary of Proposed Recovery Plan provisions related to mainstem survival of the listed salmon.

3.21 Final Environmental Impact Statement for Columbia River System Operation Review

The Columbia River SOR, a joint effort of the Corps, BPA, and BOR, was initiated on July 18, 1990 to review multipurpose management of the Columbia-Snake River System and provide a strategy for system operation. SOR started as a comprehensive, long-term study to review system operations of Federal water resource projects on the Columbia River and its tributaries in view of present and future needs of all users. The study included a technical, social, economic, and environmental analysis of alternatives for operation of the FCRPS, and an environmental analysis needed for Federal agencies to renew the Pacific Northwest Coordination Agreement (PNCA). The scope of the review included 14 major Federal projects on the Columbia River and its tributaries (12 operated by the Corps, 2 operated by BOR).

With the ESA listings of Snake River sockeye and chinook stocks in 1991 and 1992, the SOR took on a different character. It began to focus on the role that system operations could play in salmon recovery and NMFS became a key player (because of its responsibility under the ESA for determining the biological consequences of river operations).

Ten functional work groups and four analysis groups conducted work on the SOR. The functional work groups evaluated the impacts of system operation alternatives under consideration for the particular functional area represented by each work group. For example, the anadromous fish work group evaluated the alternatives to determine impacts on anadromous fish, and the water quality work group focused on water quality. Representation on each of the work groups included staff from each of the three lead Federal agencies, in addition to the states, other Federal agencies, utility and other interest groups, the tribes, and the general public.

The analysis groups examined the alternatives from a broader perspective. The River Operation Simulation Experts used computer models to determine flows and evaluations for each of the 90 alternatives for further evaluation of impacts by the technical work groups. The Economics Group analyzed direct and indirect economic impacts of the alternatives during full-scale analysis. The NEPA group guided preparation of the draft and final EIS to document all aspects of the review. The fourth group, PNCA Alternatives, was concerned with alternative forms of coordination for power.

The Draft EIS for SOR was issued in July 1994. It contained seven alternative System Operating Strategies (SOS):

SOS 1: Pre-ESA Operation—base case strategy without various measures resulting from ESA listings of anadromous fish; operations directed at power production and flood control satisfies traditional nonpower requirements at projects.

SOS 2: Current Operations—current system operations, including efforts to provide additional anadromous fish flows; flow augmentation of up to 370,200 hectare-meters (3 million acre-feet), in addition to the Water Budget; supplemental drafts from the Dworshak reservoir; flood control space shifted from the Snake River Basin to Grand Coulee Dam; lower Snake River projects near MOP levels; John Day at minimum irrigation pool level.

SOS 3: Flow Augmentation—year-round flow targets for minimum flows at Dworshak and mid-Columbia flow targets based on runoff forecasts above Grand Coulee.

SOS 4: Stable Storage Project Operation—year-round monthly elevation targets at storage projects; operations based on integrated rule curves at Libby and Hungry Horse Dams.

SOS 5: Natural River Operation—lower Snake drawdowns to natural river level; flow augmentation of up to 370,200 hectare-meters (3 million acre-feet) and Water Budget from mid-Columbia River; John Day at MOP during spring and summer; Dworshak at flood control levels.

SOS 6: Fixed Drawdown—lower Snake drawdown to spillway crest level; flow augmentation of up to 370,200 hectare-meters (3 million acre-feet) and Water Budget from mid-Columbia River; John Day at MOP during spring and summer; Dworshak at flood control levels.

SOS 7: Federal Resource Agency Operations—Alternative incorporated the operations suggested by USFWS and NMFS.

While the SOR agencies were finishing the Draft EIS in spring 1994, the U.S. District Court issued its ruling in *IDFG v. NMFS* that the 1993 Biological Opinion had failed to meet the necessary legal standard. A key issue in this lawsuit was whether enough water in the Columbia River System had been dedicated to salmon recovery and whether the new Biological Opinion must incorporate more water for fish into operations. Shortly after the *IDFG v. NMFS* ruling, the 9th Circuit Court of Appeals issued a ruling in another case, which said that the Northwest Power Planning Council (NPPC) had not given proper consideration to the recommendations of state resource agencies and tribes in preparing its Fish and Wildlife Program. Many people interpreted this decision to mean that state agency and tribal proposals should be given more weight in the operating decision. It became clear to the Federal operating agencies that the SOS that came out of SOR would need to take these legal decisions into account. In March 1995, NMFS issued its biological opinion on hydrosystem operations. Two additional decisions in lawsuits pertaining to fish operations were issued in June 1995; these decisions recognized the 1995 Biological Opinion as the guideline for operating the hydrosystem in light of the ESA.

From these events and activities, the alternatives for the Final EIS evolved. Those alternatives, as modified from the Draft EIS, were:

SOS 1a: Pre-Salmon Summit Operation—represents operations as they existed from 1983 to 1991 and includes the original Water Budget.

SOS 1b: Optimum Load-Following Operation—represents operations as they existed prior to changes resulting from the Northwest Power Act.

SOS 2c: Current Operations/No Action—represents an operation consistent with the Corp's 1993 Supplemental EIS; it includes up to 52,700 hectare-meters (427 thousand acre-feet) of additional water from above Brownlee Dam to improve fish flows.

SOS 2d: 1994-98 Biological Opinion (NEW)—matches the hydro operations contained in the 1994 to 98 Biological Opinion issued by NMFS in mid-1994.

SOS 3: (DELETED)

SOS 4c: Stable Storage Project Operation (REVISED)—applies integrated rule curves developed by Montana at Libby and Hungry Horse year-round; Dworshak and Albeni Falls are operated to specific elevations; Grand Coulee is also operated to specific elevations to provide acceptable water retention times; Grand Coulee flood central rule curves are applied only when the January-July forecast is greater than 8,400,000 hectare-meters (68 million acre-feet).

SOS 5b: Natural River Operation—draws down the lower Snake River facilities from April 16 through August 31 each year.

SOS 5c: Permanent Natural River Operation (NEW)—assumes the drawdown occurs year-round with no refill of the facilities to normal operating ranges.

SOS 6b: Fixed Drawdown Operation—draws down all four lower Snake River facilities for four and one-half months.

SOS 6d: Lower Granite Drawdown Operation—draws down only Lower Granite facility for four and one-half months.

SOS 7: (REPLACED WITH NEW ALTERNATIVES)

SOS 9a: Detailed Fishery Operating Plan—establishes flow targets at The Dalles, based on the previous year's end-of-year storage content; specific volumes of water are released from Dworshak and Brownlee, and lower Snake River facilities are drawn down to near spillway crest level for four and one-half months; specific spill percentages are established at run-of-river projects; spill caps are used to prevent excessive total dissolved gas; fish transportation is assumed to be eliminated.

SOS 9b: Adaptive Management—establishes fixed flow targets at McNary and Lower Granite Dams from April through July.

SOS 9c: Balanced Impacts Operation—establishes higher fixed flow targets, compared to SOS9b, at McNary and Lower Granite Dams.

SOS PA: Preferred Alternative (NEW)—spring and summer flow targets for the Snake and Columbia Rivers; refill to flood control levels by early spring; summer draft limits at storage reservoirs; Kootenai River white sturgeon operation; drawdown to MOP levels; increased spill levels limited by dissolved gas.

A final EIS for the SOR was completed in November 1995 (BPA, 1995). The preferred alternative included the following provisions:

- Spring and summer flow targets for the Snake and Columbia Rivers
- Refill to flood control levels by early spring
- Summer draft limits at storage reservoirs
- Kootenai River white sturgeon operation
- Drawdown to MOP levels
- Increased spill levels limited by dissolved gas.

The Corps signed the SOR ROD selecting the Preferred Alternative in February 1997.

3.22 Memorandum of Agreement for BPA Funding (System Configuration Team)

On September 16, 1996, five federal agencies involved in salmon and other fish and wildlife restoration activities in the Columbia River Basin signed a Memorandum of Agreement (MOA) to maintain BPA funding for Columbia Basin fish and wildlife activities at an average of $435 million per year for fiscal years 1996 through 2001. Regional efforts to rebuild fish and wildlife resources affected by development of the hydropower system have been funded by several sources, including BPA rate payers and various Corps appropriations. The MOA represents an effort to balance the dramatically escalating costs of fish and wildlife restoration with the need to provide BPA with a degree of financial stability in a competitive energy market. Signers of the MOA represented the Department of the Army (for the Corps), the Department of Energy (for BPA), the Department of Interior (for USFWS and BOR) and the Commerce Department (for NMFS).

3.23 Lower Snake River Juvenile Salmon Migration Feasibility Study

The current study is one of several studies under Phase II of the SCS (see Section 3.4). It was initiated in 1994 to evaluate the technical, environmental, social, and economic effects of potential modifications to the configuration of four projects on the lower Snake River in order to increase the survival of juvenile anadromous fish as they migrate through the project areas, as directed by the NMFS 1995 Biological Opinion.

The current study includes engineering work; biological investigation (i.e., effects to salmon and steelhead, resident fish, and wildlife); effects on recreation, cultural resources, and water quality; and socioeconomic effects, including implementation costs, navigation, irrigation, and power. Also included is the development of an EIS and public involvement, both of which are essential to the NEPA process.

The initial pathways being evaluated in the study included: 1) the existing system, 2) major system improvements, and 3) natural river drawdown.

In an Interim Status Report issued in December 1996 (as directed by the NMFS 1995 Biological Opinion), the Corps stated the following:

> *Findings, based on the consideration of all data, indicate that there is insufficient information at this time for the Corps to make a recommendation on the best configuration of the hydropower system to safely pass juvenile salmon in the lower Snake River. However, preliminary conclusions on the drawdown options indicate that seasonal spillway crest and seasonal natural river should be eliminated from further consideration. Consequently, the Corps recommends the continuing investigation of three courses of action to improve salmon migration: permanent drawdown to natural river, surface bypass/collection, and the current fish programs, as well as combinations of the three.*

These, then, were developed into the four alternatives that were evaluated in the Final FR/EIS:

- Alternative 1—Existing System—under current operations, as directed by the 1995 biological opinion, ocean-going juvenile salmon pass the dams through turbines, fish bypass systems, or over the spillways. In accordance with the biological opinion issued by the NMFS, the Corps also implements flow augmentation and increased spill measures to assist migration. Screens are used to guide most fish away from turbines and into a bypass system. The young salmon are then routed back to the river or to a holding area for transport downriver by barge or truck. This system is constantly being evaluated and improved by scientists and engineers. Ongoing improvements include longer screens, additional barges, and flow deflectors on spillways.

- Alternative 2—Maximum Transport of Juvenile Salmon—This alternative would include all of the existing or planned structural and operational configurations from Alternative 1—Existing Conditions. However, this alternative assumes that the juvenile fishway systems would be operated to maximize fish transport from Lower Granite, Little Goose, and Lower Monumental and that voluntary spill would not be used to bypass fish through the spillways (except at Ice Harbor). To accommodate this maximization of transport some measures would be taken to upgrade and improve fish handling facilities.
- Alternative 3—Major System Improvements—These improvements would include construction of surface bypass collection systems (fish bypass systems that divert fish beginning at a more shallow level than current systems), fish guidance improvements, turbine modifications, structural changes to reduce harmful dissolved gas levels, and possible operational changes such as modifying river flows and spills. This could include improvements to the juvenile fish transportation system or in-river juvenile migration. An adaptive migration strategy would be used to provide flexibility for utilizing either in-river or transportation approaches.
- Alternative 4—Dam Breaching—Existing reservoirs would be permanently lowered to a natural free-flowing condition by removing a section of each dam, creating a 225-kilometer (140-mile) near-natural river. This would eliminate existing reservoir-related and dam passage mortality as well as speed the downriver migration of juvenile salmon. Commercial navigation and hydropower production would cease. Irrigation and recreation opportunities would be affected.

3.24 Plan for Analyzing and Testing Hypotheses

In 1993, fishery modelers from NMFS, BPA, NPPC, the Corps, Washington, Oregon, Idaho, and the Columbia River Inter Tribal Fish Commission formed the Analytical Coordination Work Group (ANCOOR). The objective of this work group is to compare and enhance smolt passage survival and lifecycle models used within the region for salmon management evaluation. Previous model comparison and peer-review efforts demonstrated that each smolt passage survival and lifecycle modeling system has differences in basic assumptions regarding the effects of recent and potential management actions. In 1994, a Scientific Review Panel was convened to provide technical oversight to ANCOOR. The Panel concluded that there were three major differences between the modeling systems:

- The distribution of survival over the life span
- The effect of flow on survival
- The benefit of smolt transportation.

The panel believed that as long as these differences exist, the models would output different answers in a predictable manner, rendering further analysis of model structure, behavior, and usefulness a relatively unproductive activity. The panel recommended focusing on describing and resolving the fundamental divergences through hypothesis testing. This hypothesis testing process became the Plan for Analyzing and Testing Hypotheses (PATH).

3.24.1 Objectives

- Determine the level of support for key hypotheses based on existing information, and provide guidance to management agencies on the implications of these analyses for key management decisions (retrospective analyses). Propose other hypotheses and/or model improvement that are more consistent with the data.
- Assess the effects of alternative future management actions on salmon stocks, and the ability to distinguish among competing hypotheses from future information (prospective analyses). Advise various institutions (i.e., NMFS, NPPC, BPA, USFWS) on the consequences of alternative future management actions for salmon stocks, and the types of research, monitoring, and adaptive management experiments that could maximize the rate of learning and clarify decisions.

3.24.2 Process

Iteration within the PATH process occurs as this logical framework is revised over time in response to improvements in information and analytical methods, as well as changing management questions. The framework is intended to provide guidance to the development of regional programs that would stabilize, ensure persistence, and eventually restore depressed salmon stocks to self-sustaining levels. It is also meant to provide a structure for an adaptive learning approach to development and implementation of a regional salmonid recovery program. The PATH process takes a whole lifecycle approach to developing this framework to encompass potential delayed effects of stressors or processes in one life stage on subsequent life stages.

3.25 Federal Caucus

To better coordinate the Federal response to, and recovery of, ESA-listed fish species in the Columbia River Basin, the Federal Caucus was developed. The caucus consists of nine agencies with different authorities and jurisdictions:

- National Marine Fisheries Service
- US Fish and Wildlife Service
- Bonneville Power Administration
- US Army Corps of Engineers
- US Bureau of Reclamation
- Environmental Protection Agency
- US Forest Service
- Bureau of Land Management
- Bureau of Indian Affairs.

The Federal Caucus released the *Final Basinwide Salmon Recovery Strategy* on December 21, 2000. The final strategy followed the preparation of two draft documents including the *Conceptual Recovery Plan* or "All-H Paper" in December 1999 and 15 public joint hearings that also considered the Draft EIS for the Corps' Lower Snake River Juvenile Salmon Migration Feasibility Study (this document). The strategy includes seven goals:

- Conserve Species
- Conserve Ecosystems
- Assure Tribal Fishing Rights and Provide Non-Tribal Fishing Opportunities

- Balance the Needs of Other Species
- Minimize Adverse Effects on Humans
- Protect Historic Properties
- Preserve Resources Important to Maintaining Traditional Tribal Culture.

The strategy includes actions within each of the H's (habitat, hydropower, hatcheries, and harvest) that can be taken to improve survival at every lifestage. The Federal Caucus strategy complements the CRBFWP by the NPPC and supports a subbasin and watershed approach to planning and implementing projects. However, the Federal Caucus strategy is necessarily broader in scope than the CRBFWP because it proposes actions that could be taken outside the hydropower system (e.g., agriculture, forestry, industry, and municipalities) using existing authority (e.g., permitting, Clean Water Act compliance).

3.26 State Plans for Salmon Recovery

The states of Oregon and Washington have both developed and implemented programs for the recovery of listed salmon in state waters. The *Oregon Plan* was approved by voters in November 1998 and targeted for recovery of coastal stocks of salmon and steelhead. Shortly thereafter, in January 1999, Governor Kitzhaber expanded the scope of the plan to include salmon and steelhead throughout the state. Similarly, the State of Washington released the *Statewide Strategy to Recover Salmon, "Extinction is Not An Option"* in September 1999.

The Oregon Plan and Washington's Statewide Strategy have many similar components and objectives including:

- **Water Quality**—Revision of state-wide water quality standards and implementation of Total Maximum Daily Loads (TMDLs), where appropriate
- **Water Quantity**—Investigation and prioritization of instream flow for fish
- **Habitat**—Funding for estuarine, stream, and riparian restoration, preservation, and enhancement
- **Fish Passage Barriers**—Identification and prioritization for correcting passage barriers, particularly related to culverts
- **Harvest and Hatchery Management**—Marking all hatchery fish; investigating selective fishing methods; and increasing scrutiny of hatchery practices and production levels
- **Forest Practices—**Review and revision of Forest Practices Rules
- **Public Outreach**—Programs to inform citizens how they can contribute to the restoration, conservation, and enhancement of salmon habitat including potential homeowner effects on water quality and water quantity
- **Research, Monitoring, and Assessment**—Funding and implementation of state programs, coordination with regional efforts, incorporation of adaptive management, and plan reviews by independent science panels.

Some of the programs included in the Oregon Plan and Washington's Statewide Strategy are new, while others expand or refocus existing programs. A major theme to the Oregon and Washington State sponsored plans is that each provides an explicit science-based approach focused on responding to legal requirements and recovering listed salmon species.

In contrast to Washington and Oregon, Idaho does not currently have a recovery plan developed especially for listed salmon. However, Idaho has recently (May 2000) created the Office for Species Conservation, which is focused on addressing issues concerning ESA listed or potentially listed fish and wildlife species throughout the state and presenting a unified Idaho perspective to Federal agencies about these issues. All of the states participate in regional processes such as the NPPC and the CRBFWP and provide comment on federal recovery documents such as biological opinions on the FCRPS ongoing operation and maintenance activities.

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5. Glossary

Anadromous fish: Fish, such as salmon or steelhead trout, that hatch in fresh water, migrate to and mature in the ocean, and return to fresh water as adults to spawn.

Biological Opinion: A formal opinion/evaluation issued by a federal or state agency responsible for monitoring endangered or threatened wildlife. A preliminary assessment is often issued in response to an intra-agency request for information regarding species status and is designed to be incorporated into a biological opinion.

Bypass system channel: Fish diverted from turbine passage are directed through a bypass channel to a holding area for release or loading onto juvenile fish transportation barges or trucks.

Collection channel: Holding area within the powerhouse that fish enter after exiting the bulkhead slot.

Dissolved gas supersaturation: Caused when water passing through a dam's spillway carries trapped air deep into the waters of the plunge pool, increasing pressure and causing the air to dissolve into the water. Deep in the pool, the water is "supersaturated" with dissolved gas compared to the conditions at the water's surface.

Drawdown: In the context of this FR/EIS, drawdown means returning the lower Snake River to its natural, free-flowing condition via dam breaching.

Endangered species: A native species found by the Secretary of the Interior to be threatened with extinction.

Gatewell basket: A mechanical dipping basket used to remove fish from powerhouse gatewells.

Minimum operating pool (MOP): The bottom one foot of the operating range for each reservoir. The reservoirs normally have a 3-foot to 5-foot operating range.

Record of decision (ROD): A document, based on information disclosed in the Final Environmental Impact Statement, that identifies the alternative chosen, mitigation and monitoring measures to be implemented, and other information relative to the decision.

Resident fish: Fish species that reside in fresh water throughout their lifecycle.

Sanctuary dipnet: Another term for sanctuary bag, a 50-pound bag placed on the bottom of a gatewell basket. It retains fish placed in gatewell baskets pending their release into a tank truck.

Spill: Water released through the dam spillways, rather than through the turbines. Involuntary spill occurs when reservoirs are full and flows exceed the capacity of the powerhouse or power output needs. Voluntary spill is one method used to pass juvenile fish without danger of turbine passage.

Spillway flow deflectors (flip lips): Structures that limit the plunge depth of water over the dam spillway, producing a less forceful, more horizontal spill. These structures reduce the amount of dissolved gas trapped in the spilled water.

Stilling basin: A concrete-lined pool below a dam. Water passing through spillways generates tremendous energy that must be dissipated. This is accomplished by allowing the water to fall over the spillway into the stilling basin.

Surface bypass collector (SBC) system: System designed to divert fish at the surface before they have to dive and encounter the existing turbine intake screens. SBCs direct the juvenile fish into the forebay, where they are passed downstream either through the dam spillway or via the juvenile fish transportation system of barges and trucks.

Threatened species: A native species likely to become endangered within the foreseeable future.

Annex A

NPPC Fish and Wildlife Program

Details of Phase II Amendments Related to Mainstem Survival

(Source: NPPC, 1991)

Keypoints of ISG Report

(Source: ISG, 1996)

Note: This excerpt is reproduced directly from the Amendments to the Columbia River Basin Fish and Wildlife Program (Phase II) (NPPC 1991).

Details of Phase II Amendments Related to Mainstem Survival

Because of their focus on fish survival during migration in the mainstems of the Columbia and Snake Rivers, Phase II amendments have been of key concern to Federal agencies with management responsibility for dams on these rivers (Corps, BPA, BOR). Following are highlights of key measures in Phase II that relate to mainstem survival in the Columbia River basin, with an emphasis on the lower Snake River.

Mainstem Survival

Salmon and steelhead migrate to and from the sea, and their safe passage is critical. Several factors affect passage. Dams present physical barriers; the slower water in reservoirs impedes travel time; and the fish encounter predators. NPPC adopted the measure below to address these problems for both juvenile fish migrating downstream and adult fish moving back upstream. To enhance river operations, the NPPC established a Fish Operations Executive Committee made up of senior management representatives of NPPC, fishery managers and river operators to meet annually to develop an Implementation Plan that will be carried out by the Fish Passage Center. The Plan will address flows, spill, transportation, other agency plans, coordinated system operations, research and monitoring efforts and other mainstem passage matters. The following measures are designed to increase survival for salmon migrating in the rivers and for fish transported in barges.

Screens and bypass system at dams

- Completion of screens and juvenile bypass systems at all eight federal dams on the mainstem of the Columbia and Snake Rivers by 1998.
- Installation of longer screens to guide more fish away from turbines and evaluation of modifications that may be needed to accommodate reservoir drawdown measures.
- Expedited improvements at Bonneville Dam's second powerhouse, where screens have performed poorly since the powerhouse began operation in 1983. Also, expedited evaluation of fish guidance problems at Bonneville Dam's first powerhouse.

Reduction of predation

- Design and operation of bypass system outfalls to reduce predation by both fish and birds, as well as continued exploration of new fish bypass technologies.
- A 20 percent reduction of the squawfish population annually.
- Continued evaluation of the interaction between marine mammals and salmon.

Transportation of fish around dams

Moving fish in barges or trucks benefits some fish but remains controversial. Transportation decisions are made by the fish managers in cooperation with the Corps which owns and operates the trucks and barges. Transportation is called for when fish survival is expected to be greater with transportation, usually in low water years. Substantial improvements to make transportation safer and more effective are also called for.

Increased river velocities to enhance travel time

Fish survival increases as travel time decreases, but there is little consensus on the effectiveness of individual measures. NPPC believes it would be a serious mistake to use lack of consensus as a reason to take no action, especially in light of the serious state of certain runs. None of the new measures below will violate flood control limits or the Vernita Bar agreement that protects the spawning area for upriver bright fall chinook in the Hanford Reach of the Columbia River. NPPC also has given the power system flexibility on how it acts to increase storage to shape flows for fish. Immediate measures call for:

- Increased flows in the Snake River during the spring migration aimed at providing a flow equivalent of at least 85,000 cubic feet per second by lowering Snake River pools to near minimum operating level and providing additional water out of Dworshak Dam.
- Deeper drawdowns of lower Snake River reservoirs by 1995 also have been called for because the immediate measures do not appear to be enough in themselves to rebuild some of the runs. These deeper drawdowns will be implemented unless they are found to be economically or structurally infeasible, biologically imprudent, or inconsistent with the Northwest Power Act. Operations, design, mitigation, and biological plans for reservoir drawdowns are due in 1993. The measure allows for full participation by the river interest groups in development of drawdown plans and provides for independent analysis.
- Operation of Brownlee reservoir by Idaho Power Company so upper Snake River Basin water is passed to assist migrants and shifting system flood control storage from Brownlee to other Columbia projects in years when below average runoffs is forecast.
- Study of the potential for new storage in the Snake River Basin to provide additional water and a study to assess effects of changes in water quality on salmon and steelhead, as well as a regional assessment of water availability.
- Water efficiency improvements, water conservation, improved forecasting, water marketing, dry year option leasing, storage buy-backs and other measures to secure substantial additional Snake River water for spring migrants.
- Increased flows in the Columbia that aim to provide at least 200,000 cubic feet per second in the lowest water years with even higher flows in slightly better years.
- To evaluate benefits for Columbia summer migrants in low water years, provision of water from U.S. non-treaty storage and continued search for energy exchanges and other alternatives to make water available to fish.

- Due to uncertainty over the availability of out-of-region power, a call to the BPA to begin to secure options for more resources to ensure more flows for fish.
- A call to evaluate various options that could meet winter peaking needs and other power system changes that could make more water available for fish flows and reduce the impacts on the power system.

State Actions

- A call for states to conduct water availability studies, establish minimum instream flow levels, deny new water appropriations that would harm anadromous fish, and acquire water rights on a voluntary basis to improve fish flows.
- Improved enforcement of water rights at diversions, including measuring devices.

Adult fish returning to spawn

- Evaluation of the effectiveness of releasing cool water in late summer from Dworshak and Hells Canyon dams to lower water temperatures to benefit returning fall chinook and steelhead.
- Leaving bypass screens in place longer if necessary to prevent adult fish from falling back through the turbines.
- Improvements in adult ladders and operating criteria.
- Evaluation of the growing shad population to determine if it is clogging ladders and impeding adult salmon passage.
- Evaluation of video counting and monitoring adult passage with internal (PIT) tags.
- Assessment of using cool water in ladders and evaluation of the effects of zero nighttime flows on adult salmon in the lower Snake.

Note: This excerpt is reproduced directly from Return to the River: Restoration of Salmonid Fishes in the Columbia River Ecosystem. (ISG 1996).

Key Points of ISG Report

Conceptual Foundations in the Current Fish and Wildlife Program

As the ISG began development of a conceptual foundation, it looked first to the Columbia River Basin Fish and Wildlife Program to determine whether such a foundation already exists in that document. Our answer is yes and no. The Fish and Wildlife Program actually has several implied conceptual foundations. This is likely a result of the process through which it is created, in which recommendations from fish and wildlife managers and others are reviewed and adopted. Each participating agency or individual brings to the process some version of a conceptual foundation on which their recommendations are based. In nearly every instance, these conceptual foundations are not stated outright, but are only implied. In some cases, the foundations that make their way into the program through the adoption of specific measures are in conflict.

In the review of the Fish and Wildlife Program, the ISG analyzed the general assumptions that seem to determine the direction of program activities. The most fundamental assumption appears to be that the natural ecological processes that result in a healthy salmon population can be, to a large degree, circumvented, simplified and controlled by humans. Out of this context, the ISG drew three further assumptions.

1. The number of adult salmon made available to spawn is primarily a direct response to the number of smolts produced. (More young fish will automatically result in more adult spawners.)
2. Salmon production can be increased by actions taken within the river without accounting for conditions in the estuary or ocean.
3. Management actions will not compromise environmental attributes of the ecosystem that supports salmon.

These assumptions drive management toward actions that are best characterized as technological substitutes for ecological processes. They are often measures that respond to individual problems and they may be credible scientific approaches to those problems if they are reviewed in isolation: hatcheries and mechanisms for improving salmon survival at hydroelectric projects, for example, rather than actions that look at the broader context of salmon life history, behavior, and habitat. They reflect a good faith effort by the NPPC and the region's fisheries managers to recover salmon populations. However, the continuing decline of the basin's salmon populations indicates that the conceptual foundations in the current fish and wildlife programs and the actions based on those foundations are inadequate.

ISG Proposed Conceptual Foundation

The conceptual foundation the ISG proposes departs from some of those in the current program. It is not intended to validate measures in the program, nor does it derive out of those measures. It is instead designed to form a framework into which recovery measures can be integrated, when they are appropriate. It can provide a template against which recovery actions can be measured and evaluated.

In this proposed conceptual foundation, we treat the Columbia River and its tributaries as both a natural *and* a cultural system. A natural-cultural ecosystem encompasses all the ecological and social processes that link organisms, including humans, with their environments. This approach integrates the habitat of salmon and other wildlife, as well as human habitat, with land use and other cultural developments.

We draw our conceptual foundation from established ecological principles, based on what we understand about the decline of salmon populations and their habitat in the Columbia River Basin.

There are three critical elements of the conceptual foundation:

1. Restorations of Columbia River salmon must address the entire natural and cultural ecosystem, which encompasses the continuum of freshwater, estuarine and ocean habitats where salmon complete their life histories. This consideration includes human developments, as well as natural habitats.
2. Sustained salmon productivity requires a network of complex and interconnected habitats, which are created, altered, and maintained by natural physical processes in freshwater, the estuary, and the ocean. These diverse and high-quality habitats are crucial for salmon spawning, rearing, migration, maintenance of food webs and predator avoidance.
3. Life history diversity, genetic diversity, and metapopulation organization are ways salmon adapt to their complex and connected habitats. This biodiversity and its organization contribute to the ability of salmon to cope with the environmental variation that is typical of freshwater and saltwater environments.

The Natural-Cultural Ecosystem

We believe an ecosystem with a mix of natural and cultural features can still sustain a broad diversity of salmon populations in the Columbia River Basin. We call this ecosystem "normative," by which we mean an ecosystem where specific functional norms or standards that are essential to maintain diverse and productive populations are provided. In developing our definition of normative, we looked at what conditions lead to high levels of salmon productivity in less-constrained river systems, as well as in the historic Columbia River Basin.

Key among the conditions we define as normative is the availability of a continuum of high-quality habitat throughout the salmon life-cycle, from freshwater streams along the entire migratory path into and back out of the Pacific Ocean. This habitat varies from freshwater to saltwater, from fast-moving, gravel-bottom streams to deep pools and deeper seas. We assume that this habitat is dynamic, responding to daily, seasonal, annual or longer life-cycle changes. We also assume that a diverse array of salmon populations and other occupants of this habitat have adapted over time to the majority of these natural changes. Under some circumstances, salmon in mainstem reaches and adjacent subbasins of the Columbia formed groups of interconnected populations, which we refer to as metapopulations.

Development of the Columbia River for hydropower, irrigation, navigation, and other purposes has led to a reduction in both the quantity and quality of salmon habitat, and most critical, a disruption in the continuum of that habitat. Depleted salmon populations cannot rebuild if any habitat that is critical during any of their life stages is seriously compromised.

Consequently, we believe that the most promising way to help salmon populations rebuild is to reduce or remove conditions that limit the restoration of high-quality salmon habitat at each of their life history stages. Our intent in describing a normative ecosystem for salmon is to point our key characteristics that are critical to their survival and productivity. Our description is necessarily general. Specific prescriptions, such as flow regimes, levels of stock diversity, etc., will need to be developed through a process that includes policy development and trade-offs between the natural and cultural elements of the ecosystem. The normative ecosystem is also dynamic. Conditions in the normative ecosystem will vary, progressing from the current state of the river toward historic conditions, based on the region's decisions and actions.

Productivity and the Network of Habitats

The Columbia River is a complex network of habitat types from the headwaters to the estuary. Populations of salmon, as well as other fauna and flora, are distributed throughout this network, thriving wherever there are sufficient resources to sustain their growth and reproduction. Some species are relatively localized, finding adequate resources within a narrow geographic range. These include resident fish. Others, such as anadromous salmon, require vast migrations and specific conditions at each "post" in those migrations, if they are to thrive.

The system of hydropower dams on the Columbia has greatly diminished the diversity of habitat once characteristic of this watershed. The dams severed the continuum of habitat, leaving very little riverine habitat left in the mainstem and isolating other types of habitat. Dams also altered flooding and draining patterns, which further reduced available habitat types and food webs in those habitats. Two key consequences of this loss of habitat diversity have been a reduction in the biodiversity of native salmon stocks and the proliferation of non-native species. Certain species have been able to adapt to conditions created by the dams, while others have not. For example, invertebrates, fish and plants that are not native to the Columbia have proliferated in the impounded river reaches rather than in free-flowing reaches, generally because impounded habitat is more homogeneous.

Normative river conditions are re-expressed at some distance downstream from dams—the further from the dam, the more habitat recovery occurs. This has been demonstrated on the Flathead and Clearwater Rivers, for example. However, the mainstem dams on the Columbia and Snake Rivers, for the most part, preclude such resetting of habitat conditions because water released from each dam pours directly into the reservoir behind the next downstream dam. The exception is the Hanford Reach on the mid-Columbia, the last free-flowing stretch of the river. The Hanford Reach provides a model of the productivity possible in river reaches that are not fully regulated by dams. It supports a healthy population of fall chinook capable of surviving downstream migration, harvest in the ocean and return upstream to spawn.

Life History Diversity and Metapopulation Organization

In their 1996 review of the status of Pacific salmon, the National Research Council recommended that salmon be viewed as metapopulations rather than as isolated stocks. This application of metapopulation concepts to natural populations is still being debated among scientists, so our inclusion of the metapopulation structure as it applies to salmon should be viewed as a hypothesis that requires further study and confirmation.

Metapopulations are groups of local populations that are linked by individuals that stray among the populations. Metapopulations persist through the mechanism of straying. When local populations become extinct, they can be re-established through colonization by strays from neighboring local populations. We believe that metapopulation structure is likely in salmon because these fish display both a high degree of homing to their natal streams, which establishes the groups of local populations, and a variable level of straying, which provides the dispersal of genetic traits needed to successfully recolonize habitat vacated by lost populations.

Studies indicate that the most abundant salmon spawning populations likely occurred in river segments with well-developed floodplains and gravel bars, where habitat complexity was high, including areas suitable to spawning, egg incubation, and juvenile rearing. We conclude that salmon populations spawning in large alluvial mainstem reaches of the Columbia may have served as core populations and, as such, may have played critical roles in sustaining salmonid populations in the basin.

Loss of prime mainstem spawning habitat for core populations, and further losses from fragmentation, isolation and degradation of habitats in tributary systems, could have significantly reduced the long-term persistence and stability of regional salmon production. For example, most fall chinook that spawned in the mainstem Columbia and Snake Rivers are now extinct.

One of the only surviving mainstem populations and fall chinook spawns is in the Hanford Reach in the mid-Columbia. This is the largest naturally spawning population of chinook salmon above Bonneville Dam, and it has been stable during the years when salmon in other parts of the basin have undergone severe decline. It is possible that fall chinook in the Hanford Reach now function as a core population, which might serve as a source for colonization of adjacent habitats if normative conditions were restored in those areas.

Isolated population of salmon are less likely to be recolonized should they be driven toward extinction because they may lack adjacent populations with similar genetic traits. For the same reason, surviving isolated populations also have less likelihood of successfully contributing to efforts to replenish declining populations elsewhere in the basin. As populations become isolated, local extinctions become permanent, and the entire metapopulation moves toward extinction. Therefore, we believe that restoring salmon populations in this basin will require both the restoration of more diverse habitat conditions and the reconnecting of habitats into the continuum necessary to support salmonids at every stage of their life histories. If this continuum can be restored, we believe that metapopulations will re-emerge to help stabilize regional salmon populations against environmental fluctuations.

Assessment of the Fish and Wildlife Program

In its review of the scientific basis of the Fish and Wildlife Program, the ISG assigned a qualitative rating that summarized its assessment of the scientific support for various assumptions. Its numeric rating ranked assumptions and principles based on what we deem the "level of proof." "Level one" would apply to an assumption for which there is solid peer-reviewed empirical evidence. "Level two" would be backed by strong evidence, but not conclusive evidence. "Level three" assumptions have theoretical support with some evidence. "Level four" assumptions are speculative, with little empirical evidence to support them. Finally, "level five" assumptions are contradicted by good evidence to the contrary. Chapters 4 through 10 contain our analysis of the data we reviewed to establish these conclusions.

The ISG first reviewed three general principles that appear in both the NPPC's program and in the Northwest Power Act.

1. *The salmon bearing ecosystem in the Pacific Northwest and northeast Pacific Ocean has considerable excess carrying capacity.* Level of proof: four. This assumption leads to the further assumption that there is a simple relationship between the numbers of smolts and increasing overall productivity over the long term. What confounds this assumption is the complexity of both freshwater and marine conditions. In-river, estuary, and ocean environments fluctuate dramatically in response to both human-caused and environmental changes. The key to resilience in a variable environment is not just the numbers of smolts nor the quantity; it is the diversity of both habitat and genetic traits that is critical to restoring Columbia Basin salmon.
2. *Abundance of salmon and steelhead in the Columbia River Basin has, to a significant degree, declined due to, and is presently limited by, human actions*. Level of proof: one. This assumption is irrefutable. Even accounting for natural variation in the environment, decline of most species has closely paralleled the development of the basin. Damage from early and ongoing development has removed substantial portions of the basin from access by salmon, altered remaining habitat, reduced the abundance of salmon and decreased the ability of surviving salmon populations to cope with natural environmental variations. Focusing only on hydropower impacts severely constrains the region's ability to reverse these trends.
3. *Ecosystem functions lost as a result of development of the Columbia River can be replaced by technological solutions to individual problems*. Level of proof: four. The best evidence against this assumption is the continuing decline of the basin's salmon populations. While technology will continue to be part of any restoration effort in the Columbia River, the ISG recommends that the region move from a strategy of "fixing" ecosystem damage to one that places greater reliance on re-expression of the natural biological and physical processes of the Columbia River salmon-bearing ecosystem.

The ISG also analyzed 29 specific assumptions contained in the Fish and Wildlife Program, assigned a numeric ranking to each, and provide in Chapter 3 a brief overview of the science supporting our ranking. In Chapters 4 through 10, we expand on this evidence.

General and Specific Conclusions Related to Mainstem Survival

As the ISG noted, restoration of Columbia River Basin salmon populations will require a new definition and understanding of the salmon ecosystem. Humans have transformed the Columbia River Basin from a thriving natural environment to a great hydroelectric, irrigation, and transportation system, one that drives this region's economy. The human approach to salmon recovery has reflected these impressive technological accomplishments: hatcheries have attempted to replace natural productivity, flow augmentation has attempted to replace the spring freshet, barge transportation has attempted to replace inriver migration, and so on. To reverse the decline of salmon populations, we believe the region must endorse a conceptual foundation for salmon recovery, such as the one previously described, and base its efforts on that foundation.

The key to salmon productivity in the future will be the degree to which normative ecosystem conditions are re-introduced into the Columbia River Basin. To accomplish this return to normative conditions, we recommend the following.

Recognize explicitly that salmon in the Columbia River Basin exist naturally as collections of locally adapted populations organized into aggregates of core and satellite populations known as metapopulations. To increase total productivity, management decisions should nurture life history and population diversity. That diversity will require protection for the remaining core populations, and restoration and reconnection of potential core habitats at strategic areas within the basin. The Hanford Reach, the last free-flowing stretch of the Columbia, could be a model for this management approach.

Protect and restore freshwater habitat for all life history stages, with a focus on key Columbia River and tributary reaches and lakes. This approach would include: restoration of the spring freshet to revitalize in-river habitats; stabilization of daily fluctuations in flows to allow food webs to persist in shallow-water habitats that are important juvenile rearing areas; provision of incentives for watershed planning that emphasized riparian and upland land-use activities to enhance instream and lake habitats. Wherever possible, reconnect restored tributary habitats to restored mainstem habitats, particularly where remnant core populations, such as the Hanford Reach fall chinook, exist.

Manage stocks with a more complete understanding of migratory behavior and the limitations that migratory behavior could place on river operations. From their review, the ISG concluded that the Columbia and Snake Rivers should not be treated merely as conduits through which young salmon passively migrate to the sea. On the contrary, the young fish have ecological requirements that must be met during their downstream migration through the mainstem habitat. Fishery managers need to better understand these needs and manage accordingly.

Reduce sources of mortality throughout the salmonid ecosystem, including the ocean and the estuary, as well as the rivers and tributaries of the Columbia River Basin.

Current and future salmon recovery measures should correspond to the normative ecosystem concept and be evaluated for their effectiveness in meeting stated objectives. For example, an approach whose goal is a normative ecosystem would highlight restoration of life history diversity, rather than more technological approaches, such as transporting fish in barges or producing them in hatcheries. Hatcheries and transportation should only be used selectively and experimentally, and they should be monitored carefully. The has attempted to replace as a whole needs an integrated ecosystem monitoring and evaluation program.

Annex B

Summary of Proposed Snake River Salmon Recovery Plan Provisions Related to Mainstem Survival

(Source: NMFS, 1995b)

Note: The following is reproduced directly from the Proposed Recovery Plan for Snake River Salmon (NMFS 1995b)

Summary of Proposed Recovery Plan Provisions Related to Mainstem Survival

The goal of the Proposed Recovery Plan is to restore the health of the Columbia and Snake River ecosystem and to recover listed Snake River salmon stocks. Many of the recommended actions will directly benefit other species such as other salmon stocks, sturgeon, and bull trout. Implementation of the Proposed Recovery Plan should also conserve biodiversity, a factor that is essential to ecosystem integrity and stability. Many of the actions in the Proposed Recovery Plan have been used to formulate reasonable and prudent measures in current Section 7 consultations.

The Proposed Recovery Plan discusses the natural history and current status of Snake River salmon. It also addresses known and potential human impacts, and displays the costs directly attributable to recovery. In addition, the Proposed Recovery Plan identifies delisting criteria and biological objectives, and proposes the tasks required to meet them. Tasks are identified in the areas of institutional structure, tributary ecosystem, mainstem and estuarine ecosystem, harvest management, and artificial propagation.

NMFS' approach to Snake River salmon recovery places highest priority on ameliorating the primary factors for the species' decline and eliminating existing impediments to recovery. The Plan does this by proposing actions that offer immediate benefits, and refining those actions over time to ensure the most efficient use of limited resources. This strategy incorporates an adaptive management process; it allows actions to be added, deleted, or refined as important scientific information and analyses becomes available.

Mainstem Ecosystem

In the mainstem ecosystem, salmon face problems associated with their downstream and upstream migrations. The journey through the lower Snake and Columbia Rivers has become more hazardous since eight hydroelectric dams were built and their reservoirs created. Each dam delays juvenile fish in their transition to the ocean environment and exacts additional losses. Seventy percent of the 482 miles between the mouth of the Columbia River and Lewiston/Clarkston on the Snake River has been converted from free-flowing river into reservoirs. This change has slowed the rate of downstream travel for smolts and increased the amount of habitat favorable to predator species. Hatchery fish and exotic species compete with and prey on the listed salmon in the mainstem ecosystem.

NMFS examined various approaches to improving the downstream survival of juvenile Snake River salmon (as well as that of other fish that migrate through the corridor). The actions considered include improving in-river and dam passage conditions, improving collection and transportation systems for juvenile migrants (especially under adverse river conditions), and drawing down reservoirs.

NMFS proposes to proceed on a long-term adaptive management approach that will depend upon a combination of improved in-river migration conditions, improved transportation, and major structural changes at dams. The Proposed Recovery Plan recommends a major decision point when sufficient adult survival information is available in 1999. In the interim, all necessary studies, planning, design, and environmental documentation for drawdowns should be completed. At the same time, in-river migration conditions should be improved to the maximum extent possible using techniques such as increased flows, increased spill, physical improvement of the dams, and aggressive surface bypass development and testing. Significant improvements should also be made in transportation operations. The overall approach is to proceed on a path that implements measures in the short term that are most likely to increase survival while at the same time enhancing our ability to isolate and address major causes of mortality in the future. Ultimately, the purpose of this approach is to determine whether there can be sufficient improvements to in-river survival and transportation to recover listed fish without major drawdowns. The listed and unlisted fish also need improvements in their upstream passage conditions. To accomplish this, the Proposed Recovery Plan prescribes actions such as installing extended length screens, operating turbines at peak efficiency for fish passage, extending the period during which the juvenile bypass system is in operation, implementing a dissolved gas abatement program, remedying water pollution problems, developing emergency auxiliary water supplies for adult fishways, and decreasing water temperatures.